TRILOBITES FROM THE CONISTON LIMESTONE GROUP (ASHGILL SERIES) OF THE LAKE DISTRICT, ENGLAND

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ABSTRACT. Five trilobite species from the Coniston Limestone Group of the southern Lake District are redescribed, on the basis of type and topotype material, and one new genus, four new species, and one new subspecies erected. A lectotype of *Sphaerexochus*? *boops* Salter is designated and topotype material described; the species is placed in *Pseudosphaerexochus*. *Encrinurus kingi* Dean is redescribed and placed in *Erratencrinurus*, for which a type species is designated; this represents the first record of this genus in Britain. A lectotype of *Calymene subdiademata* McCoy is selected; material from northern England previously assigned to *C. marginata* (Shirley) is referred to *C. subdiademata*. *Chasmops marri* (Reed) is redescribed and placed in a new genus, *Toxochasmops*; the pygidium and hypostome are described for the first time. The thorax and hypostome of *Acidaspis magnospina* Stubblefield are described for the first time and a lectotype designated. *Ascetopeltis apoxys* sp. nov., *Paraharpes whittingtoni* sp. nov., *Gravicalymene susi* sp. nov., *Primaspis bucculenta* sp. nov., and *Tretaspis convergens* Dean *deliquus* subsp. nov. are described. The evolution of *T. convergens* in northern England and its distribution and relationships with other contemporaneous species of *Tretaspis* are discussed. Trilobites from the Coniston Limestone Group described by McCoy (1851) are re-evaluated.

OUTCROPS of the Coniston Limestone Group in the southern part of the Lake District (Cumbria) occur in a narrow strip, rarely more than one hundred metres across, which trends north-east to south-west. The most easterly outcrops occur on the southern side of Shap Fells. Outcrops occur intermittently to the south-west towards Lake Windermere, principally in Longsleddale, Kentmere, and Troutbeck. Well-exposed outcrops occur to the south-west in the region of Coniston, and Torver and Ashgill Becks, thence intermittently to Millom in the extreme south-west of the Lake District (see McNamara *in press*, fig. 1).

Considering the relatively large amount of research on this Group that has been undertaken (particularly in the latter part of the nineteenth century), our knowledge of the faunas is very limited. These rocks had been studied by some estimable geologists in the nineteenth century, notably Sedgwick, Hughes, Nicholson, Harkness, and Marr. However, the only purely palaeontological work to result from their researches were descriptions by McCoy (1851) (which included *Calymene brevicapitata* Portlock, *C. subdiademata* McCoy, *Lichas subpropinqua* McCoy, *Zethus atractopyge* McCoy, *Zethus rugosus* Portlock, *Cheirurus clavifrons* Dalman, and *Illaenus rosenbergi* Eichwald); Salter (1864), who described *Sphaerexochus*? *boops*, and Reed (1894), who described *Chasmops marri*. In the twentieth century only four workers have dealt specifically with trilobites from the Coniston Limestone Group in the southern Lake District: Stubblefield (1928) described *Acidaspis magnospina*; Whittington (1950) described and figured two harpids which he referred to *Paraharpes* cf. *hornei* (Reed); Temple (1952) described and figured species of *Dalmanitina*; and, most recently, Dean (1963*a*) has described a meagre trilobite fauna from the Stile End Formation, in which he identified and described one new species, *Encrinurus kingi*. In

[Palaeontology, Vol. 22, Part 1, 1979, pp. 53–92, pls. 7–12.]

addition, Ingham (1968, 1970) has recently illustrated *Cybeloides* (*Paracybeloides*) *girvanensis* (Reed) and the types of *Illaenus marshalli* Salter from the southern Lake District.

The aim of this paper is threefold: to describe one new genus, four new species, and one new subspecies; to redescribe *Calymene subdiademata*, *Sphaerexochus*? *boops*, *Encrinurus kingi*, *Chasmops marri*, and *Acidaspis magnospina*; to re-evaluate McCoy's (1851) diagnoses of Coniston Limestone Group trilobites. A list of the trilobites found in the Coniston Limestone Group is given elsewhere (McNamara, *in press*).

Terminology. The terminology of Harrington *et al.* (*in* Moore 1959) is followed, except that 'branch' is preferred to 'section', with regard to the facial suture, and 'hypostome' is preferred to 'hypostoma' or 'labrum'. Where ambiguity may arise when terms such as 'long', 'broad', etc. are used, they are qualified by the use of the terms 'sagittal', 'exsagittal', and 'transverse' (sag., exsag., and tr.). In describing the lateral glabellar lobes and furrows the abbreviations 1p, 2p, etc. are used, numbering from the rear. The tubercle notation for *Encrinurus* devised by Tripp (1957) is utilized, as is the notation for describing the character of trinucleid pits devised by Bancroft (1929) and modified by Ingham (1970) and Hughes *et al.* (1975). One new term, the 'orle furrow' is introduced to describe the furrow near the anterior margin of the frontal lobe in species of *Chasmops*, close to, and parallel with, the preglabellar furrow. The term is derived from the seventeenth-century word 'orle', which describes a border within a heraldic shield a short distance from its edge. The stratigraphical terminology is that of McNamara (*in press*).

Temple (1975*a*, pp. 462–466) has discussed various orientations which may be employed for the purpose of describing, measuring, and photographing trilobites. A single orientation encompassing all morphological types is impractical. For this study cephala were orientated, where possible, with eye lobes lying along a horizontal plane. If eye lobes were not present, the posterior margin of the occipital ring was set vertically. Pygidia were orientated with the dorsal surface of the first axial ring lying along a horizontal plane. The method of orientation of trinucleids is that suggested by Hughes *et al.* (1975, p. 546), the anterior and posterior fossulae lying along a horizontal plane.

Preservation of material. All the specimens have been decalcified and are preserved as internal and external moulds in mudstone, calcareous mudstone, calcareous siltstone, and argillaceous limestone. These rocks have suffered unidirectional post-lithification deformation which has resulted in distortion of the fossils (see Pl. 9, figs. 9, 10 and Pl. 11, figs. 1, 3 for typical examples). The deformation is greater in the mudstone than in the limestone. As a consequence of this distortion of the fossils, comparisons cannot be made between length and breadth unless the specimen appears to be relatively undistorted. Consequently comparisons of relative dimensions are made along single axes. This allows for comparison between forms which are either longitudinally, laterally, or obliquely compressed. This method can be employed only so long as the rock has suffered only a single period of deformation which is unidirectional. Such is the case with the material from the southern Lake District. The degree of deformation of the rocks, and consequently the fossils, increases in a south-westwards direction across the southern Lake District.

The material described is housed in: the Sedgwick Museum, Cambridge (prefix SM), the British Museum (Natural History) (BM), the Institute of Geological Sciences (GSM), and the Hunterian Museum, Glasgow (HM). The locality numbers for the topotype material of existing species and for the material of new species are explained elsewhere (McNamara *in press*, figs. 2–6, Appendix 1).

SYSTEMATIC PALAEONTOLOGY

Family PROETIDAE Salter, 1864
Subfamily PROETINAE Salter, 1864
Genus ASCETOPELTIS Owens, 1973*a*

Type species. By original designation, *Ascetopeltis bockeliei* Owens, 1973*a*, p. 125, figs. 1M, N and 2A–K, from the Harjuan, Tretaspis Series, Stage 5a, Holmen, Oslo-Asker district, Norway.

Discussion. The similarity of species of *Ascetopeltis* to some species which have been included in *Proetus* (s.l.) has been discussed by Owens (1973*a*, p. 126). The main differences he noted between the two genera are in pygidial features and surface sculpture. In addition the glabella of *Ascetopeltis* appears to be shorter in relation to its width, with a more broadly rounded anterior. *Ascetopeltis* is restricted to the Ashgill Series (Owens 1973*b*, p. 27).

Ascetopeltis apoxys sp. nov.

Plate 7, figs. 1–9; text-fig. 1

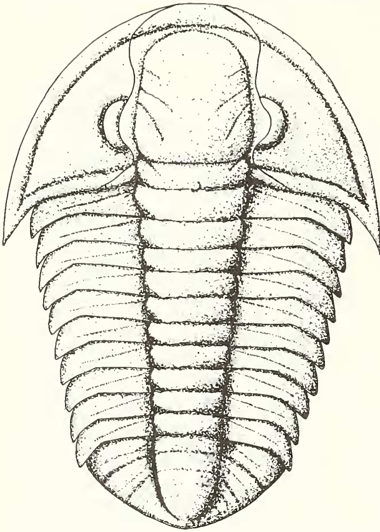
Holotype. SM A98177, internal mould of cranidium (Pl. 7, fig. 1) from the Stile End Formation (Cautleyan Stage, Zone 2) 450 m north-north-west of Stockdale Farm, Longsleddale (locality 8b).

Paratypes. HM A15430, internal mould of incomplete, articulated specimen (Pl. 7, fig. 4) from Kentmere (locality 41a); SM A98157, external mould of cranidium (Pl. 7, fig. 2) from locality 8b; SM A98159, internal mould of librigena (Pl. 7, fig. 7) from locality 7b; SM A98085, internal mould of pygidium (Pl. 7, fig. 3) from locality 7b.

Material, localities, and horizon. Forty-seven exuviae have been collected from the quarries in the Stile End Formation north-north-west of Stockdale Farm, Longsleddale (localities 7a, 7b, 8a, 8b). The paratype articulated specimen (HM A15430, Pl. 7, fig. 4) and a cranidium (HM A15431, Pl. 7, fig. 5) were collected by Dr. J. K. Ingham from the same horizon at Kentmere (locality 41a).

Diagnosis. Preglabellar furrow slightly under half length (sag.) of anterior rim; convex anterior rim as wide (tr.) as base of glabella, tapers abruptly laterally; anterior branches of facial suture weakly divergent to border furrow then strongly convergent anteriorly; eye lobe short; pleural and interpleural furrows of pygidium well-incised anteriorly; pygidial axis broad and long.

Description. Cranidium longer than broad; moderately convex. Large, tumid, gently tapering glabella occupies seven-tenths cranidial length; widest posteriorly; slightly constricted at mid-glabellar length (Pl. 7, fig. 6); broadly rounded anteriorly. Bears three pairs of shallow glabellar furrows: 1p most prominent, extending transversely for a short distance in from axial furrow at one-third glabellar length from occipital furrow, then recurves strongly to run almost exsagittally towards occipital furrow which it fails to meet (Pl. 7, fig. 2); 2p furrow short, directed more transversely than 1p; 3p furrow set a little closer to 2p furrow than 2p is to 1p; fainter and shorter than 2p furrow. Axial furrow well incised. Occipital furrow narrow (exsag. and sag.) and deep; transverse medially, directed forwards abaxially. Occipital ring more strongly vaulted than glabella; narrower (tr.) than posterior of glabella; weak occipital lobe present laterally (Pl. 7, fig. 4); bears small occipital node which is set closer to posterior border (Pl. 7, fig. 1). Eye lobe short, one-quarter cranidial length (Pl. 7, fig. 2) and set far back opposite posterior part of glabella, extending from opposite 2p lobe to close to occipital furrow. Anterior branches of facial sutures run parallel from eye lobe then are weakly divergent anteriorly to border furrow from where they converge strongly. Their posterior course is unknown, but posterior position of eye (Pl. 7, fig. 8) suggests that angles ϵ and ξ (see Owens 1973*b*, p. 4) are not independent angles. Anterior part of fixigena quite strongly convex; rapidly narrows adaxially (Pl. 7, fig. 2). Preglabellar furrow narrow (sag.), less than half length of anterior rim. Whole preglabellar area only occupies one-sixth of cranidial length. Anterior rim convex sagittally; strongly acuminate abaxially (Pl. 7, figs. 1, 2); as wide (tr.) as posterior of glabella. Librigena (Pl. 7, figs. 7, 8) triangular;

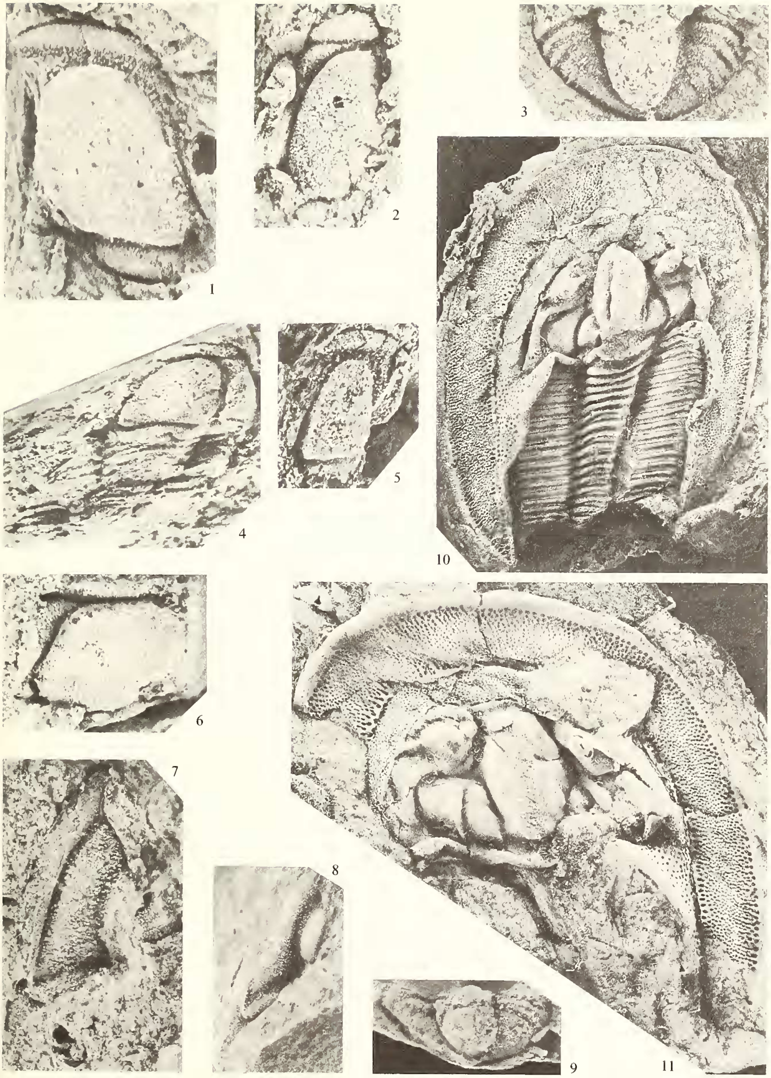


TEXT-FIG. 1. Dorsal reconstruction of *Ascetopeltis apoxys* sp. nov., approximately ×6.

EXPLANATION OF PLATE 7

Figs. 1–9. *Ascetopeltis apoxys* sp. nov. Stile End Formation (Cautleyan Stage, Zone 2). 1, holotype, SM A98177, dorsal view of internal mould of cranidium, from Stockdale, Longsleddale (locality 8b), ×8. 2, paratype, SM A98157, dorsal view of cast of external mould of cranidium, from same locality as 1, ×8. 3, paratype, SM A98085, dorsal view of internal mould of pygidium, from Stockdale, Longsleddale (locality 7b), ×8. 4, paratype, HM A15430, dorsal view of incomplete, articulated specimen, from Kentmere (locality 41a), ×6. 5, HM A15431, dorsal view of internal mould of cranidium, from same locality as 4, ×7. 6, SM A98087, dorsal view of internal mould of cranidium, distortion having enhanced glabellar constriction; from same locality as 3, ×8. 7, paratype, SM A98159, dorso-lateral view of internal mould of librigena, from same locality as 3, ×6. 8, SM A98088, dorso-lateral view of internal mould of librigena, from same locality as 3, ×7. 9, SM A98204, dorsal view of internal mould of pygidium, from Stockdale, Longsleddale (locality 8a), ×6.

Figs. 10, 11. *Paraharpes whittingtoni* sp. nov. Applethwaite Formation (Cautleyan Stage, Zone 2), north of Waterhead House, Coniston. 10, holotype, GSM 74456a, dorsal view of cast of external mould of near-complete individual, ×2; also figured by Whittington (1950, pl. 5, fig. 1). 11, paratype, GSM 74456b, dorsal view of cast of external mould of incomplete cephalon, ×2; also figured by Whittington (1950, pl. 5, fig. 2).



McNAMARA, Coniston trilobites

bounded by strongly convex rim and deep furrow; lateral border thickens anteriorly; posterior border thickens and flattens abaxially; short genal spine developed. Prominent eye socle reaches back to posterior furrow. Cheek below eye convex and strongly declined.

Thorax only known from incomplete, distorted specimen (Pl. 7, fig. 4) which bears eight segments. Axis occupies half thoracic width anteriorly, but narrows posteriorly; it is strongly vaulted; each axial ring separated from articulating half-ring by deep furrow. Pleurae bear prominent furrows; strongly declined distally and acuminate.

Pygidium (Pl. 7, figs. 3, 9) subtriangular, nearly twice as wide as long. Large axis occupies two-fifths pygidial width anteriorly and reaches almost to posterior border; gently tapered posteriorly; broadly rounded at posterior; strongly vaulted and gently convex longitudinally. Bears six axial rings; anterior interannular furrow deep, succeeding one shallow posteriorly, being ill defined sagittally. Axial furrow broad and shallow. Pleural area gently convex, bearing at least three, possibly four, pleurae. Pleural and interpleural furrow equally well incised anteriorly, more prominent laterally; become progressively shallower posteriorly. Anterior pleural band a little broader than posterior band.

Discussion. Ascetopeltis apoxys is similar to the only other described species of *Ascetopeltis* from Britain, *A. barkingensis* Owens, 1973*b*, collected from an erratic boulder of presumed upper Ordovician in age, from Barking, Dent, Yorkshire (Owens 1973*b*, p. 26). *A. apoxys* differ from *A. barkingensis* in a number of features. It has deeper glabellar furrows, narrower (tr.) occipital ring, and more posteriorly positioned occipital node. The preglabellar furrow is longer in *A. apoxys*; it is one-third the length of the anterior border in *A. barkingensis*, not one-half as given by Owens (1973*b*, p. 26) in the species diagnosis. The anterior border of *A. apoxys* is narrower (tr.) and tapers more strongly laterally than in *A. barkingensis*, while the anterior branch of the facial suture is less divergent initially. The eye is positioned further back in *A. apoxys*, the anterior part of the fixigena is more convex, and the pygidial furrows are more deeply incised. *A. apoxys* is also similar to the type species *A. bockeliei* Owens (1973*a*, p. 126, fig. 2) from the late Ashgill of the Oslo region; however, this species possesses a longer eye lobe, shorter (sag.) preglabellar furrow, shallower lateral border furrow, and longer genal spine. *A. lepta* Owens (1973*a*, p. 130, fig. 3E–G, J), from the same horizon as *A. bockeliei*, has a more cylindrical glabellar and longer preglabellar furrow than *A. apoxys*.

Family HARPIDAE Hawle and Corda, 1847 [*non* Bronn, 1849]
Genus PARAHARPES Whittington, 1950

Type species. Harpes (*Eoharpes*) *hornei* Reed, 1914, p. 10, pl. 2, figs. 1, 2; from the upper Drummuck Group, Girvan; by subsequent designation of Whittington (1950, p. 11).

Paraharpes whittingtoni sp. nov.

Plate 7, figs. 10, 11

1892 *Harpes Doranni* Portlock; Marr, p. 108.
1950 *Paraharpes* cf. *hornei* (Reed); Whittington, pp. 41–42, pl. 5, figs. 1, 2.

Holotype. GSM 74456a, the external mould of an almost complete articulated individual (Pl. 7, fig. 10) from the Applethwaite Formation (Cautleyan Stage, Zone 2) at 'Coniston Waterhead'; figured by Whittington (1950, pl. 5, fig. 1).

Material, locality, and horizon. Whittington (1950, p. 41) was unsure both of the horizon and the locality from which the holotype and the paratype (GSM 74456b, Pl. 7, fig. 11) were collected. It seems likely they originated from an outcrop north of Waterhead House, 2 km east-north-east of Coniston (SD 321984). The specimens of *P. whittingtoni* are preserved in calcareous mudstone characteristic of the Applethwaite Formation. The only other harpid material known from the Coniston Limestone Group in the southern Lake District are fragments of harpid fringe from the High Pike Haw Formation (Cautleyan Stage, Zone 2) at High Pike Haw. These, however, cannot be specifically determined.

Diagnosis. Brim has about eighteen irregular rows of pits lying in a rough quincuncial pattern; twelve rows occur on the cheek roll. Brim of constant anterior and lateral width. Prolongation shorter than length (sag.) of cephalon; internal rim almost straight. Eye lobe set far forward.

Description. Cephalon two-thirds as long as broad. Bordered by wide brim which occupies a little over one-quarter cephalic length (sag.); of even width anteriorly and laterally to end of cheek roll, then tapers strongly posteriorly; almost flat and covered by many pits which are arranged in a rough quincuncial pattern; pits close to external rim are larger than inner pits; pits increase in size close to internal border (Pl. 7, fig. 11). There are approximately eighteen concentric rows of pits in brim, though they are not always well defined as many small pits are developed which tend to break up the more regular pattern of larger pits. Prolongation shorter than length of cephalon, being estimated to end approximately opposite twentieth thoracic segment; tapers strongly posteriorly, internal rim being almost straight. Cheek roll horizontal anteriorly, inclining to about 45° postero-laterally opposite alae; narrower than brim, bearing about twelve irregular rows of small pits anteriorly. Cheek roll prolongation wide anteriorly, tapering strongly posteriorly; bears large pits arranged in a quincuncial pattern. Girder is weakly developed. External rim narrow, convex; internal likewise. Glabella occupies a little under one-half cephalic length; strongly convex; widest posteriorly where subtriangular posterior lobe present, this being set much lower than rest of glabella; anteriorly glabella contracts abruptly, anterior width being two-thirds posterior. Posterior glabellar furrows deeply incised and straight; anteriorly divergent at about 40°; narrow posteriorly, broaden near mid length, then narrow to axial furrow (Pl. 7, fig. 11). Preglabellar furrow short (sag.) and shallow. Axial furrow runs exsagittally forwards from posterior border to anterior of basal lobe, then runs gently inwards to preglabellar furrow; shallow posteriorly, but much deeper and broader anteriorly. Ala wider (tr.) than basal lobe, semicircular, inner half strongly convex, outer half lower and flatter. Raised, pitted, gently convex cheek narrowest (tr.) outside ala, widens anteriorly, less so posteriorly; central part of wide anterior portion bears conical eye lobe which is set a little lower than posterior of glabella but higher than basal lobe and ala; set far forward opposite anterior of glabella. Prominent eye ridge (Pl. 7, fig. 10) runs inwards and forwards to antero-lateral corner of glabella. Occipital furrow deep and wide (sag.) narrows (exsag.) abaxially. Occipital ring strongly vaulted and short (sag. and exsag.); bears anteriorly positioned median glabellar node (Pl. 7, fig. 11).

Thorax (Pl. 7, fig. 10) incomplete, only fifteen segments preserved. Broadens posteriorly to fourth segment, then of constant width to eleventh, posterior to which it narrows strongly. Axis tapers gently backwards and occupies one-third thoracic width anteriorly, one-quarter posteriorly. Articulating half ring long (sag.) and narrows abaxially to deep axial furrow. Pleurae bear a prominent, oblique furrow, anterior and posterior pleural bands of equal length (exsag.). Pleurae horizontal to distal fulcrum; then steeply decline for one-sixth pleural width (tr.).

Discussion. Whittington (1950, p. 41) preferred not to erect a new species for this form, as the horizon and locality were uncertain. The near-certainty that it is from the Applethwaite Formation, the good preservation of the material, and the discovery of further important differences between it and *P. hornei* (Reed 1914, p. 10, pl. 2, figs. 1, 2) seem to justify the foundation of a new species. *P. whittingtoni* has a greater number of more well-ordered pits in the brim than *P. hornei* (18 as opposed to 12–14) and more pits in the cheek roll (12 as opposed to 8–10). The prolongation of *P. whittingtoni* is shorter and less strongly curved, being less than the length of the cephalon, whereas it is more than the cephalic length in *P. hornei*, extending to the twenty-third segment (Whittington 1950, p. 39). The brim of *P. hornei* broadens laterally around the cephalon, but remains of even width in *P. whittingtoni*. The preglabella area of *P. whittingtoni* is relatively longer than that of *P. hornei*. The glabella of *P. hornei* is much longer than broad, whereas it is slightly broader than long in *P. whittingtoni*.

The axial furrow is deeper and broader in *P. whittingtoni* resulting in a well-defined glabella. The eye lobe is set further forward relative to the glabella in *P. whittingtoni*. The eye ridge, prominent in *P. whittingtoni*, is not apparent in the holotype of *P. hornei*. The thorax tapers less strongly in *P. whittingtoni* than in *P. hornei*. *P. costata* (Angelin), redescribed by Warburg (1925, pp. 214–224, pl. 5, figs. 1–6) from the Boda Limestone of Sweden, differs from *P. whittingtoni* in having a much shorter glabella and more gently tapered, longer prolongation. Dean (1971, pp. 8–10, pl. 2, figs. 4, 6) has described *P. costata* from the Chair of Kildare Limestone in Eire on one incomplete cephalon. This has a glabella which is much narrower posteriorly than in *P. whittingtoni* and narrower alae. *P. ruddyi* Whittington (1950, p. 42, pl. 5, figs. 6–8, pl. 6, figs. 1–3) from upper Ashgill strata in Wales has a similar brim form to *P. whittingtoni*, but has fewer, larger pits.

Family TRINUCLEIDAE Hawle and Corda, 1847
Subfamily TRINUCLEINAE Hawle and Corda, 1847
Genus TRETASPIS McCoy, 1849

Type species. Subsequently designated by Bassler 1915, p. 1285, *Asaphus seticornis* Hisinger, 1840, p. 3, pl. 37, fig. 2; from the Fjäcka Formation, Dalarna, Sweden.

Tretaspis convergens Dean, 1961 *deliquus* subsp. nov.

Plate 8, figs. 1–8; text-figs. 2, 3

1916 *Trinucleus seticornis* (Hisinger); Marr, p. 199 (pars.).
1916 *Trinucleus bucklandi* Barrande; Marr, pp. 199, 202.
1970 *Tretaspis hadelandica* Størmer *brachystichus* Ingham; Ingham, p. 49 (pars.).

Holotype of subspecies. SM A99006, external mould of a cephalon and incomplete thorax (Pl. 8, figs. 1–4) from the Torver Formation (Cautleyan Stage, Zone 3) between Torver Beck and its first tributary (locality 22e).

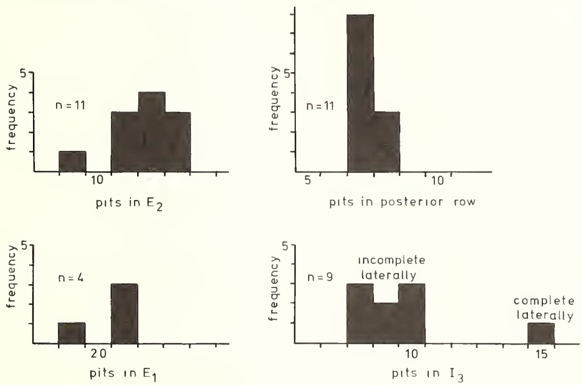
Material, localities, and horizons. Two complete articulated specimens plus numerous cephalic fragments are known from the Torver Formation around Torver Beck and its tributaries (localities 21e, 22e), Old Pits Beck (locality 35b), and Willy Scrow (locality 25a). Two specimens have been collected from the upper part of the Applethwaite Formation (Cautleyan Stage, Zone 3) at Garbourn Nook (locality 19), whilst three specimens were collected by Dr. J. K. Ingham from this horizon at Kentmere (locality 41b_2).

Diagnosis. Subspecies of *Tretaspis convergens* in which arc I_4 of the fringe is never developed. Arc I_3 is absent frontally, and may be either complete or incomplete laterally; where laterally incomplete 8–10 pits persist.

Description. Apart from the fringe, the characters of the cephalon and thorax of *T. convergens deliquus* are largely like those of *T. convergens convergens* described by Dean (1961, p. 127) from the Pusgillian of the Cross Fell Inlier, and by Ingham (1970, p. 45) from the same stage in the Cautley district. Ingham (1970, p. 46) observed a transverse row of tubercles behind the anterior margin of the axial ring but this does not appear to be present in *T. convergens deliquus*.

On the fringe four arcs of pits present anteriorly. E_1 and I_1 pits share sulci to bR_9 or bR_{10}, though further apart after bR_5, then diverge, following which E_3 is developed from about bR_{14}. E_1 possesses twenty-one pits (half fringe) (text-fig. 2). E_3 only developed laterally; shares sulci with E_1 on upper lamella but not on lower. Laterally pits in E_1 and E_2 are smaller than anteriorly. There are eight to thirteen pits in E_2 (half fringe), ending one pit short of posterior row, which contains seven to nine pits. In front of glabella aR radii consist of I_2 and I_n, I_3 being absent frontally (Pl. 8, figs. 2, 5). Pits in I_3 appear at aR_3 and persist to aR_{11-13} in all specimens (text-fig. 2). In some specimens pits from aR_{14} to posterior row are present (Pl. 8, fig. 3) whereas in others pits are absent between aR_{13} and aR_{16} (Pl. 8, figs. 5, 7). On upper lamella I_n and I_3 share sulci laterally but not anteriorly. On lower lamella pits in I_2, I_3, and I_n share deep radial sulci; I_1 sometimes has pits in the same sulci but only when aligned with inner pits. I_2-I_n are radially aligned, as are I_1, E_1, and E_2, the two sets being out of phase with one another (Pl. 8, fig. 5).

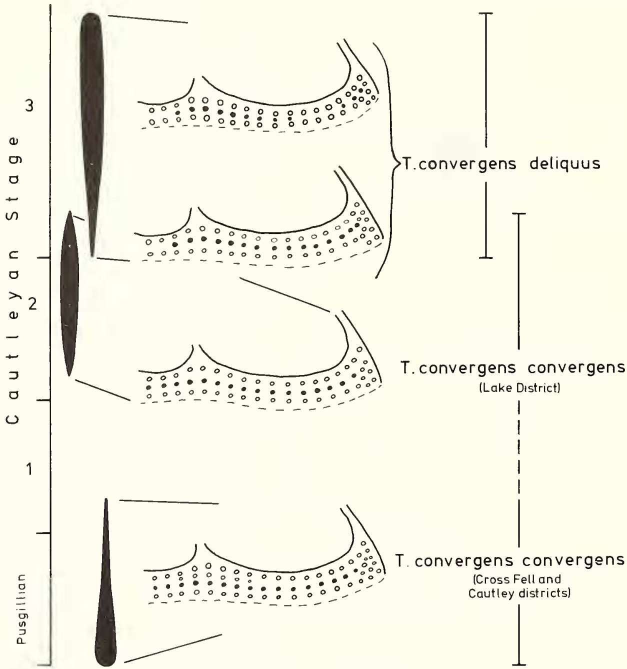
The pygidium (Pl. 8, figs. 6, 8) of *T. convergens* has not hitherto been described. Its maximum breadth (tr.) is about three times sagittal length. Anterior border straight, transverse; postero-lateral border broadly convex, lateral margin steeply declined. Axis occupies one-quarter anterior pygidial width; gently convex transversely; bears five furrows which are broad (sag.) and shallow medially; opposite these, in axial furrow, deep apodemal pits present. Axial furrow is broad and shallow. Pleural area bears a prominent anterior pleural furrow which broadens laterally; second furrow very shallow and narrow close to axial furrow, broadening and deepening abaxially. A faint third furrow exists as an elongate, broad, shallow depression a little behind broad part of second furrow (Pl. 8, figs. 6, 8). Posteriorly border arches up behind axis (Pl. 8, fig. 8) and bears a deep medial invagination.



TEXT-FIG. 2. Histograms of selected fringe characters (half fringe data) in *Tretaspis convergens* Dean *deliquus* subsp. nov.

Discussion. T. convergens convergens, which Dean (1961, pp. 127–129, pl. 9, figs. 1–6) described from the upper Pusgillian Dufton Shales of the Cross Fell Inlier, is characterized by a strongly swollen frontal lobe which overhangs the fringe anteriorly, and coarsely reticulated frontal lobe and genae. The fringe of the Cross Fell material contains arcs I_2, I_3, and I_n, which are present frontally (text-fig. 3), and I_4 which has eight to ten pits (Ingham 1970, p. 45) but is incomplete both laterally and frontally. Ingham (1970, p. 45, pl. 6, figs. 1–12) has described *T. convergens convergens* from the Pusgillian and early Zone 1 of the Cautleyan Stage of the Cautley district. In contrast to the Cross Fell specimens, the Cautley form has fewer pits in I_4 (0–4) and a wider range of pits in the posterior row (7–12). In the Lake District *T. convergens deliquus* is common in Zone 3 in the Torver Formation and occurs rarely in the upper part of the Applethwaite Formation, which is also of Zone 3 age (McNamara *in press*). In the lower and middle parts of the Applethwaite Formation (Zone 2) *T. convergens convergens* is locally common. Like the Cautley form, the Lake District form of *T. convergens convergens* has fewer pits in I_4 than the Cross Fell form, but it continues a trend towards decreasing the number of pits in this row by generally having I_4 absent (although I_3 is complete frontally and laterally) (text-fig. 3) though specimens from one locality (15a) contain two pits in I_4.

This trend in reduction of the number of pits is continued in *T. convergens deliquus*, I_3 becoming discontinuous frontally and, in many specimens, discontinuous laterally. Ingham (1970, p. 49) thought that specimens of *Tretaspis* which he collected from the upper part of the Applethwaite Formation (Zone 3) at Kentmere (locality $41b_2$)



TEXT-FIG. 3. Diagrammatic representation of inner part of fringe (I_2–I_n) in subspecies of *Tretaspis convergens* Dean, illustrating their relative stratigraphic positions in northern England; data of *T. convergens convergens* in the Pusgillian and early Zone 1 from Ingham (1970); filled circles represent arc I_3.

were *T. hadelandica* Størmer *brachysticus* Ingham on account of the presence of a laterally incomplete row of pits in arc I_3. Comparison of these specimens with recent collections from the Lake District shows Ingham's specimens to belong to *T. convergens deliquus*. This subspecies has also been collected from the Applethwaite Formation at Garbourn Nook (locality 19).

The decrease in number of pits in the fringe in the *T. convergens* lineage is in direct contrast to the morphological changes in pit number displayed by the *T. hadelandica* lineage in Rawtheyan strata (Ingham 1970, pp. 46–50) and in the early lineages of the *T. moeldenensis* group in upper Caradoc and early Ashgill strata at Cautley (Ingham 1970, pp. 50–55). The disappearance of *T. convergens* from Cautley during Zone 1, but its presence in Zones 2 and 3 in the Lake District might be accounted for by the increase in dominance of species of the *T. moeldenensis* group in Cautley during the early Cautleyan. Whereas *T. convergens convergens* was able to coexist with an early member of the *T. moeldenensis* group, *T. colliquia* Ingham, *T.* cf. *moeldenensis* Cave became dominant during Zone 1 (Ingham 1970, p. 54) and so may have forced out *T. convergens convergens*. The absence of members of the *T. moeldenensis* group from the Lake District, the continuance here of *T. convergens convergens* and the development of *T. convergens deliquus*, suggest a barrier to migration of species of *Tretaspis* between Cautley and the Lake District during Zones 2 and 3. During the hiatus in the Lake District between Zones 4 and 6, the *T. convergens* lineage became extinct. The barrier between the two regions must have been broken by late Zone 6 as *T.* aff. *latilimbus* (Linnarsson) *distichus* Ingham, a form intermediate between *T. hadelandica brachystichus* and *T. latilimbus distichus*, is present in the White Limestone Formation in the Lake District.

Whereas the *T. convergens* lineage shows a decrease in number of pits in the fringe, the *T. hadelandica* group shows an increase by the completion of I_3, then the development of arc I_4. As a consequence of this, homeomorphy of fringe characters occurs between the *T. convergens* and *T. hadelandica* lineages, which may result in some confusion in the naming of subspecies using fringe characters alone. Consequently, *T. convergens convergens* from the Pusgillian and *T. latilimbus distichus* from the upper Rawtheyan display a similar fringe morphology. Similar homeomorphy exists between the Cautleyan *T. convergens deliquus* and the Rawtheyan *T. hadelandica brachystichus*, both species having an incomplete number of pits in I_3. The two forms can be distinguished, however, by the larger frontal lobe of *T. convergens deliquus* and its coarser, more complete cephalic reticulation, and by the smaller number of pits in I_3 frontally in older *T. hadelandica brachystichus* than in *T. convergens deliquus*. The Lake District *T. convergens convergens* from Zones 2 and 3 is like *T. hadelandica hadelandica* (which is probably from the Gagnum Shale of Gran, Hadeland (Ingham 1970, p. 49)), I_3 being complete laterally.

The pygidium of *T. convergens deliquus* is similar to that of *T. hadelandica brachystichus* but differs in bearing five axial furrows, not six; similarly the pleural area bears three furrows, not four. Species of the *T. moeldenensis* group generally bear more than six axial furrows.

Family CHEIRURIDAE Hawle and Corda, 1847
Subfamily ECCOPTOCHILINAE Lane, 1971
Genus PSEUDOSPHAEREXOCHUS Schmidt, 1881

Type species. Sphaerexochus hemicranium Kutorga, 1854, p. 112, pl. 1, fig. 2: from the Aseri Stage (C_{1a}), Estonia; by subsequent designation of Reed (1896).

Discussion. The form described here, *Pseudosphaerexochus boops*, has never been formerly assigned to any genus with certainty. The ovate form of the glabella and form of the glabella lobes is characteristic (Lane 1971, p. 45) of *Pseudosphaerexochus*, to which genus *P. boops* is now referred.

Pseudosphaerexochus boops (Salter, 1864)

Plate 8, figs. 9–14

1851 *Ceraurus clavifrons* Dalman; McCoy, pp. 154 (*pars*), 338 (*pars*), pl. 1F, fig. 12, 12a.
1864 *Sphaerexochus? boops* Salter (*pars*), p. 79, pl. 6, fig. 28, *non* 27.
1868 *Cheirurus juvenis* Salter; Nicholson, p. 54.
1873 *Sphaerexochus boops* Salter; Salter, p. 50.
1878 *Sphaerexochus boops* Salter; Marr, p. 873.
1888 *Cheirurus bimucronatus* Murchison; Aveline *et al.*, p. 55.
1888 *Sphaerexochus boops* Salter; Aveline *et al.*, p. 55.
1891 *Sphaerexochus boops* Salter; Woods, p. 151.
1892 *Sphaerexochus boops* Salter; Marr, p. 109.
1974 *Pseudosphaerexochus? boops* (Salter) (*pars*); Price, pp. 850–852, pl. 113, fig. 11, *non* 10.

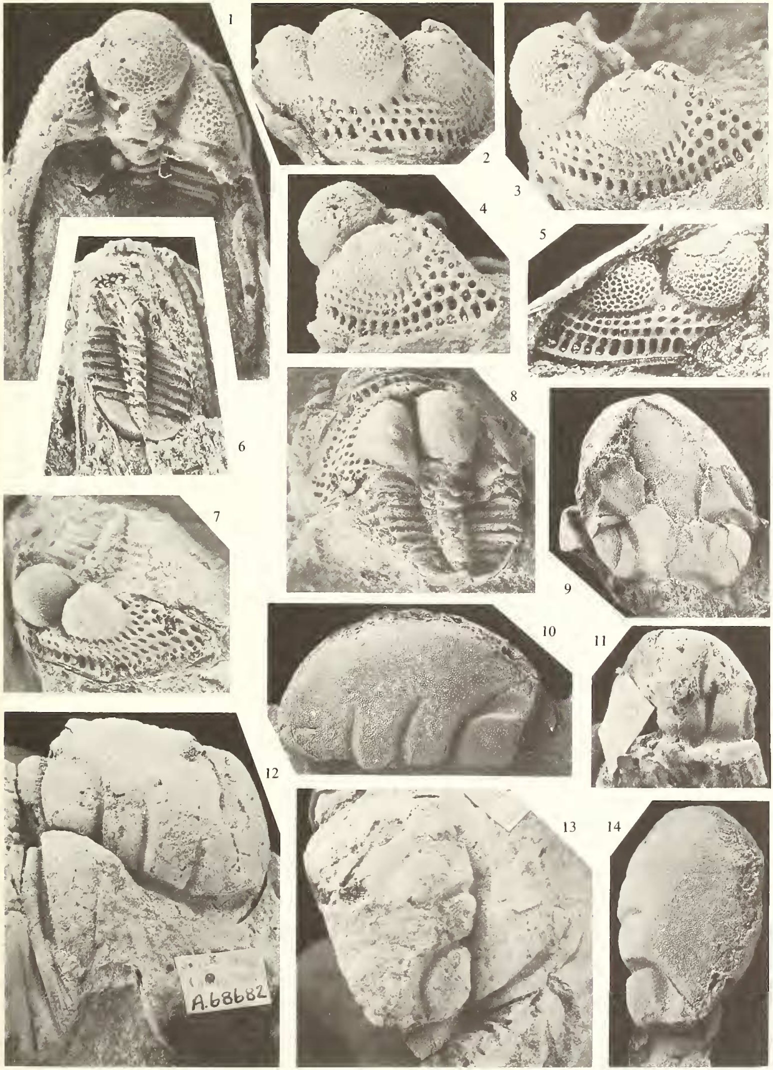
Lectotype. Herein selected: SM A41905, internal mould of a distorted cranidium (Pl. 8, figs. 9, 11) from the Applethwaite Formation (Cautleyan Stage, Zone 2), 'Applethwaite Common'; figured by McCoy 1851, pl. 1F, fig. 12; Salter 1864, pl. 6, fig. 28; Price 1974, pl. 113, fig. 11.

Material, localities, and horizon. Three other specimens of this species are known: an incomplete cranidium from the same horizon and locality as the lectotype; another from a similar horizon south of Nettle Crag, Torver (collected by Mr. T. C. Nicholas); a badly deformed cranidium collected by Dr. J. K. Ingham, from a similar horizon at Stunfel Howe (locality 14) can probably be referred to this species.

EXPLANATION OF PLATE 8

Figs. 1–8. *Tretaspis convergens* Dean *deliquus* subsp. nov. Torver Formation (1–4, 6–8) and upper Applethwaite Formation (5) (both Cautleyan Stage, Zone 3). 1–4, holotype of subspecies, SM A99006, from Torver (locality 22e), cast of external mould of incomplete individual, 1, dorsal, 2, anterior, 3, antero-lateral, 4, lateral views, all ×6: pits in row I_3 complete laterally. 5, SM A98729, antero-lateral view of cast of external mould of incomplete cephalon, from Garbourn Nook (locality 19), showing row I_3 incomplete laterally, ×6. 6, SM A43178, dorsal view of internal mould of almost complete individual, from Torver (locality 21e), showing length of genal spines, ×4. 7, 8, SM A43181, antero-lateral, 7, and dorsal, 8, views of internal mould of incomplete individual, from Torver (locality 23e), ×$3\frac{1}{2}$.

Figs. 9–14. *Pseudosphaerexochus boops* (Salter), Applethwaite Formation (Cautleyan Stage, Zone 2). 9, 11, lectotype, SM A41905, dorsal, 9, and lateral, 11, views of internal mould of distorted cranidium; 11 shows greater exsagittal length of 3p lobe over 2p lobe; from 'Applethwaite Common', ×$1\frac{1}{2}$; also figured by McCoy (1851, pl. 1F, fig. 12, 12*a*), Salter (1864, pl. 6, fig. 28), and Price (1974, pl. 113, fig. 11). 10, 14, SM A99016, lateral, 10, and dorsal, 14, views of internal mould of cranidium, from Nettle Crag, Torver (locality 43), ×2. 12, 13, SM A68682, lateral, 12, and palpebral, 13, views of internal mould of incomplete cranidium, from 'Applethwaite Common', ×2.



McNAMARA, Coniston trilobites

Emended diagnosis. Glabella ovate and broadly rounded anteriorly; bears three pairs of glabellar lobes of which 3p is longer (exsag.) than 2p, whilst 1p is longer than 3p. 3p furrow runs almost transversely. Relatively narrow central glabellar area between sub-quadrate basal lobes. Ornamentation on glabella of fine granules with fewer coarse tubercles.

Description. Glabella ovate, approximately two-thirds as broad as long, widest at 2p lobes; almost flat postero-medially, declining anteriorly from opposite 3p lobes at approximately 70° to vertical. Transversely gently convex medially, steeply declined laterally; broadly rounded anteriorly. 1p lobe longest (exsag.), sub-quadrate, bounded by deep 1p furrow which runs inwards and slightly backwards from axial furrow, then curves back strongly at one-quarter glabellar width, progressively shallowing to meet occipital furrow (Pl. 8, figs. 9, 13). Delineated 1p lobe occupies a little under one-third posterior glabellar width; 2p furrow parallel to abaxial part of 1p furrow, but shallower; extends in as far as does outer part of 1p furrow; 2p lobe shorter than 1p lobe (exsag.), being two-thirds its length; 3p furrow directed more transversely than 2p or 1p furrows; shallower and a little shorter than 2p; 3p lobe a little longer than 2p lobe, but shorter than 1p lobe (Pl. 8, figs. 10–12); lengthens adaxially (Pl. 8, fig. 10). Frontal lobe short, occupying one-tenth glabellar length. Preglabellar furrow deep, lying below overhanging frontal lobe (Pl. 8, fig. 12). Anterior border rolled; almost transverse medially, curving back strongly abaxially. Occipital furrow shallow medially, curving back strongly abaxially. Occipital furrow shallow medially, deeper abaxially; appears to curve forwards on lectotype, but this is thought to have been caused by distortion; it probably runs transversely (Pl. 8, fig. 14). Occipital ring imperfectly known, gently convex medially, declining strongly abaxially. Eye lobe not preserved but thought to be situated opposite 2p lobe (see Pl. 8, fig. 12). Posterior branch of facial suture directed almost transversely from eye lobe, curving back strongly close to genal angle. Posterior border furrow deep adaxially, shallows abaxially. Posterior border is roll-like. Fixigena narrows (exsag.) abaxially; pitted. Glabella covered by an ornamentation of fine granules interspersed with larger tubercles (Pl. 8, figs. 9, 10).

Discussion. Salter (1864) based this species on two specimens: one from 'Applethwaite Common', originally described by McCoy (1851, pl. 1F, fig. 12) as *Ceraurus clavifrons*, the other from the Sholeshook Limestone of south Wales, which have since been refigured by Price (1974, pl. 113, figs. 10, 11). The Welsh specimen, which only has the basal glabellar lobes and posterior part of the glabella preserved, has been compared with the Lake District form both by Salter and Price due to the apparently strongly curved occipital furrow. As Price (1974, p. 852) suggests, the Sholeshook specimen has undergone distortion, as has the Lake District specimen. Consequently the curved occipital furrow is thought to have been caused by distortion and is not considered to be diagnostic. The Sholeshook specimen is not considered to be the same species as the Lake District form as the 1p lobe is relatively larger and the posterior of the central glabelar area is relatively narrower; this form may represent a distorted specimen of *P. juvenis* (Salter). Price's assertion that the 3p lobe of the Lake District form is shorter than the 2p is erroneous. He based his opinion on the dorsal view alone, whereas, in fact, the anterior of the glabella has been strongly bent beneath the cranidium and the 3p lobe is longer (Pl. 8, fig. 11). Although Lane (1971) omits to mention *P. boops* in his account of the British cheirurids, the characteristic form of the glabellar lobes is considered distinctive enough to warrant the retention of the species.

P. boops is closest to *P. juvenis* and *P. octolobatus* (McCoy). *P. juvenis* (Salter 1848, p. 344, pl. 7, figs. 1, 2, 3, 3a) from the Sholeshook Limestone has an ovate glabella, but more tapered frontal lobe than *P. boops* (Price 1974, pl. 113, figs. 5, 6); the 2p lobe is longer than the 3p. In *P. octolobatus* (McCoy 1849, p. 407; Lane 1971, p. 48, pl. 8, figs. 1–8) from the Bala Limestone, which also occurs in the Applethwaite Formation and in the overlying Torver Formation, the ornamentation is like that of

P. boops, but the glabella is more sphaerical and the 2p and 3p lobes are of equal length. *P. ekphyma* Lane (1971, p. 46, pl. 9, figs. 1, 4, 5) from the upper Drummuck Group at Girvan has an ovoid glabella which like *P. boops* is broadly rounded anteriorly, but the 2p lobe is longer than the 3p.

Family ENCRINURIDAE Angelin, 1854
Subfamily ENCRINURINAE Angelin, 1854
Genus ERRATENCRINURUS Krueger, 1971

Type species. Erratencrinurus nebeni Krueger, 1971, p. 1144, pl. 1, fig. 7; pl. 2, figs. 1, 2; from the Oandu (D_3) and Rakvere (E) Stages of the glacial boulders of Germany; herein designated.

Discussion. Krueger (1971) erected *Erratencrinurus* on specimens of middle and upper Ordovician age from the glacial boulders of north Germany. Typically encrinurids possess a number of large glabellar tubercles associated with smaller adventitious ones. *Erratencrinurus* is typified by having either a pair of very large tubercles or spines in row II or III, or a single spine or tubercle in row I. The species from the Lake District which Dean (1963a, p. 53) assigned to *Encrinurus* based principally on pygidial characters, is reassigned to *Erratencrinurus* as the cranidium, which is now known, shows the inner pair of glabellar tubercles in row III to be much larger than others on the glabella. This is the first known occurrence of this genus in Britain. Other penecontemporaneous species from Britain previously referred to *Encrinurus* have recently been placed in a new genus, *Celtencrinurus*, by Evitt and Tripp (1977, p. 119). This genus is typified by the possession of the large tubercle III-0, and a median furrow on the anterior border of the cranidium.

Erratencrinurus kingi (Dean, 1963a)

Plate 9, figs. 1–7; text-fig. 4

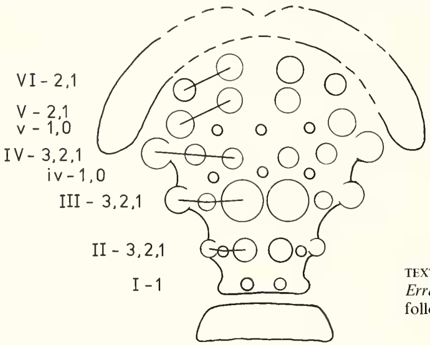
1963*a* *Encrinurus kingi* Dean, pp. 53–54, pl. 1, figs. 6, 7, 12; pl. 2, figs. 1, 2, 7.

Holotype. SM A51706, internal mould of a pygidium (Pl. 9, fig. 4) figured by Dean 1963*a*, pl. 2, fig. 1; from the Stile End Formation (Cautleyan Stage, Zone 2) in the quarries above Stockdale Farm, Longsleddale.

Material, localities, and horizons. In addition to the five specimens (one incomplete cranidium, a fragment of fixigena, and three pygidia) figured by Dean (1963*a*, pl. 1, figs. 6, 7, 12; pl. 2, figs. 1, 2, 7), there is also an almost complete cranidium (BM It8328) collected by W. B. R. King (as were Dean's specimens) from the same horizon as the holotype and paratypes. In the Sedgwick Museum collection there are two further pygidia which were collected from the High Pike Haw Formation at 'Millom Park' in the extreme south-west of the outcrop of the Coniston Limestone Group. A cranidium of this species has been collected by the author from 1·5 km north-west of Millom (locality 39). A number of fragmentary specimens have also been collected from behind Kentmere Hall (locality 33) in the Stile End Formation. Thus this species is restricted to the Stile End and High Pike Haw Formations (Cautleyan Stage, Zone 2).

Emended diagnosis. Frontal lobe wide, nearly three times posterior glabellar width. Tubercle formula: I-1, II-3, 2, 1; III-3, 2, 1; (iv-1, 0); IV-3, 2, 1; (v-1, 0); V-2, 1; VI-2, 1 (text-fig. 4). Librigena pitted, bearing only a few tubercles below the eye. Pygidium with twenty-five axial rings and eleven pleurae.

Description. Cranidium subtriangular, convexity unknown due to flattening. Glabella broadest across frontal lobe; narrows posteriorly to almost one-third frontal lobe width. Frontal lobe occupies about one-third glabellar length (sag.) and is well rounded anteriorly. Anterior border broad and convex; separated from frontal lobe by deep, broad furrow. Glabellar carries three equi-spaced, tuberculate, glabellar lobes which increase in size anteriorly (Pl. 9, figs. 2, 5). These are separated from one another by short, slot-like furrows. Posterior to 1p lobe a narrow (sag. and exsag.) raised band runs across glabella and widens just prior to meeting axial furrow. The band is bounded anteriorly by a shallow furrow which narrows adaxially, and posteriorly by a deeper furrow of more constant depth (Pl. 9, figs. 2, 5). Occipital ring long (sag.) occupying two-sevenths cranidial length. Occipital furrow broad (sag. and exsag.) and shallow. Axial furrows deep but broad, gently divergent from occipital furrow, more strongly divergent anterior to 3p lobe. Fixigena strongly convex; narrow (tr.) anteriorly but widens abruptly posterior to eye lobe. Eye lobe set opposite 1p furrow at a distance from axial furrow equal to width of glabella across 2p lobes. Posterior branch of facial suture meets lateral border a little anterior to genal angle; anterior branch runs forwards and inwards at 45°, then runs obliquely across frontal lobe below false preglabellar ridge. Librigena (Pl. 9, fig. 7) known only from an incomplete specimen which lacks anterior portion. It consists of a broad, convex border which is directed horizontally adaxially, then declines outwards, through 90°, and a steeply declined triangular area adaxially. Glabella is covered by coarse tubercles, the notation for which is given in the diagnosis. Size of the tubercles is variable: those of row I are small, central pair of row II is larger, whilst central pair of row III is much larger still (Pl. 9, fig. 6); in row IV, central pair is as large as

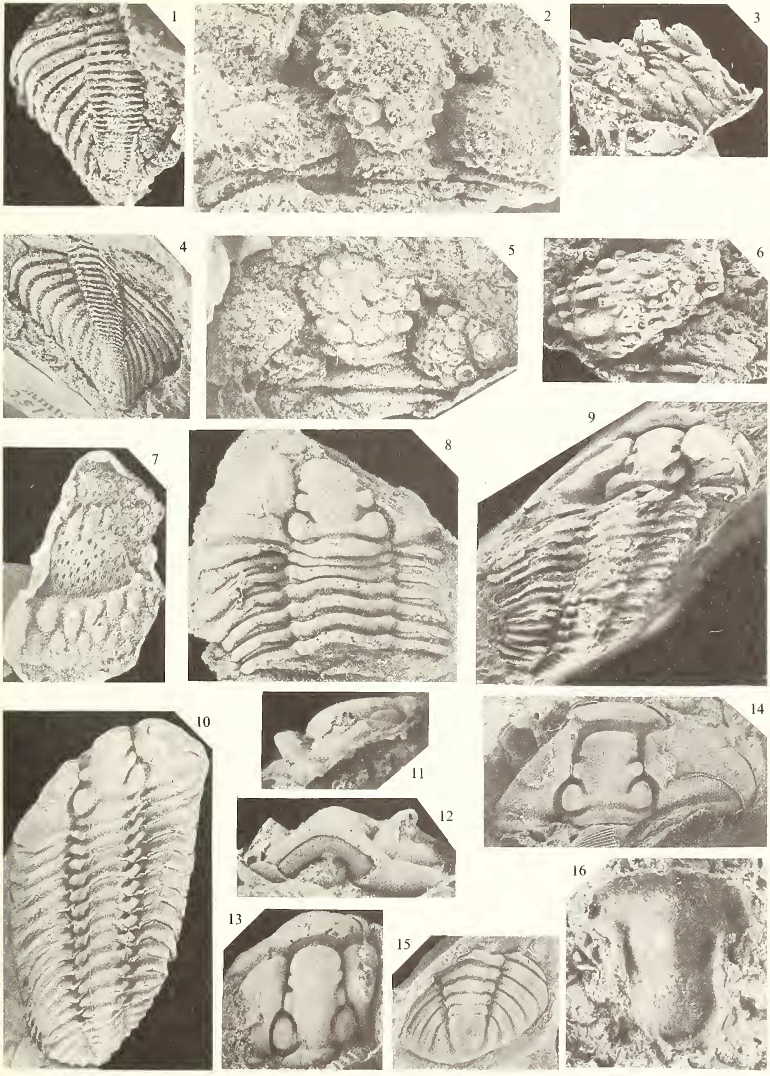


TEXT-FIG. 4. Glabellar tubercle arrangement in *Erratencrinurus kingi* (Dean); tubercle notation follows that of Tripp (1957).

EXPLANATION OF PLATE 9

Figs. 1–7. *Erratencrinurus kingi* (Dean), Stile End (2–7) and High Pike Haw (1) Formations (Cautleyan Stage, Zone 2). 1, SM A72668, dorsal view of internal mould of pygidium, from Millom (locality 39), ×4. 2, 5, BM It8328, dorsal views of internal mould, 2, and cast of external mould, 5, of cranidium, from Longsleddale (locality 11), both ×4. 4, holotype, SM A51706, dorsal view of internal mould of pygidium, from Stockdale, Longsleddale (locality 8c), ×3; also figured by Dean (1963*a*, pl. 2, fig. 1). 3, 6, SM A98248, antero-lateral, 3, and dorsal, 6, view of cast of external mould of incomplete, distorted cranidium showing the large pair of glabellar tubercles in row III, from Kentmere (locality 38), both ×4. 7, BM It8329, lateral view of cast of external mould of librigena, from same locality as 2, ×4.

Figs. 8–16. *Calymene* (s.l.) *subdiademata* McCoy, Applethwaite Formation (Cautleyan Stage, Zones 2 and 3). 8, SM A98619, dorsal view of cast of external mould of incomplete individual, from Moor Head, Troutbeck (locality 17a), ×2. 9, lectotype, SM A6806, dorsal view of external mould of distorted individual, from 'Coniston Water', ×3; also figured by McCoy (1851, pl. 1F, fig. 10). 10, SM A43551, dorsal view of internal mould of complete individual, from 'Applethwaite Common', ×2. 11, 12, 13, SM A98910; lateral, 11, ×2½, anterior, 12, ×4, and dorsal, 13, ×2½, views of cast of external mould of cranidium, from Garbourn Nook (locality 19). 14, SM A98911, dorsal view of internal mould of cephalon, from Garbourn Nook (locality 19), ×2. 15, SM A98558, dorsal view of cast of external mould of pygidium, from Garbourn Road, Troutbeck (locality 15b), ×1½. 16, SM A98900, ventral view of internal mould of hypostome, from same locality as 11, ×4½.



McNAMARA, Coniston trilobites

inner pair in row II. Only small tubercles are developed on the frontal lobe. Anterior border bears unknown number of large tubercles. Fixigena is covered by many large tubercles, whereas steeply declined librigena is pitted, bearing only a single row of tubercles below elevated eye. Border of librigena bears three rows of tubercles in a quincuncial pattern (Pl. 9, fig. 7); rows decrease in size outwards. Posterior border and genal spine are smooth.

Hypostome and thorax are unknown. Pygidium has been adequately described by Dean (1963*a*, pp. 53–54); however, it is not, as Dean states, 'twice as long as broad' but only slightly longer than broad (Pl. 9, figs. 1, 4; Dean 1963*a*, pl. 2, fig. 1).

Discussion. Erratencrinurus kingi appears to be most closely related to the type species, *E. nebeni* Krueger, which is late Caradoc in age. Although both have a similar tubercle arrangement, *E. kingi* bears an extra pair of tubercles in row III and no median tubercle in row II. Although the development of an enlarged pair of glabella tubercles is the main feature which relates *E. kingi* to the German species of *Erratencrinurus*, it also has a similar pygidium. The German forms bear eight to eleven pleurae; *E. kingi* has eleven. Whilst most German species possess more than thirty axial rings, *E. kauschi* Krueger, like *E. kingi*, has only twenty-five. The pygidium of *E. kauschi* is also similar to *E. kingi* in over-all shape, but has one fewer pair of pleurae. *E. kingi* was considered by Dean (1963*a*, p. 53) to bear five tubercles on the occipital ring; in fact only four tubercles are present on the specimen (SM A51705; Dean 1963*a*, pl. 1, fig. 7) and they lie on row III of the glabella, not the occipital ring. *Celtencrinurus multiplicatus* Reed (1901, p. 107, pl. 7, fig. 3) from the 'Middle Bala at Barking, Dent' is known from a pygidium which bears a similar number of pleurae to *E. kingi*. However, the posterior pleura meets the axis much farther forwards in *C. multiplicatus*. It also seems to possess two more axial rings, but the poor preservation of the holotype makes this difficult to ascertain with certainty.

Family CALYMENIDAE Milne Edwards, 1840
Subfamily CALYMENINAE Milne Edwards, 1840
Genus CALYMENE Brongniart, 1822

Type species. Calymene Blumenbachi Brongniart 1822, p. 11, pl. 1, fig. 1*a*, *b*; from the Wenlock Limestone, Wren's Nest, Dudley, Worcestershire.

Discussion. Temple (1975*b*, pp. 147–149) has questioned the emplacement of a number of late Ordovician and early Llandovery species in *Diacalymene* as the upturned anterior part of the preglabellar area lacks a transverse dorsal keel typical of *D. diademata* (Barrande), from the Silurian of Bohemia. Instead, these forms possess an anterior border which bears an anterior keel and a posterior ridge, the intervening area varying in orientation between horizontal, as in '*D. marginata*' Shirley, gently inclined, as in '*D.*' *crassa* Shirley, and steeply inclined, as in '*D.*' *drummuckensis* (Reed). These species show features more in common with *Calymene*, but until the type species, *C. blumenbachi* Brongniart, is redescribed fully, it is thought advisable, as suggested by Temple (1975*b*, p. 149), to refer the species to *Calymene* (*sensu lato*).

Calymene (s.l.) *subdiademata* McCoy, 1851

Plate 9, figs. 8–16

?1845 *Calymene blumenbachi* Brongniart; Sedgwick, p. 445.
1851 *Calymene subdiademata* McCoy, pp. 166–167, pl. 1F, fig. 10, *non* 9.

1868 *Calymene subdiademata* McCoy; Nicholson, p. 53.
1878 *Calymene senaria* (Conrad); Marr, p. 873.
1888 *Calymene subdiademata* McCoy; Aveline *et al.*, p. 55.
?1892 *Calymene blumenbachi* var. *caractaci* Salter; Marr, p. 108.
1913 *Calymene planimarginata* Reed (*pars*); Marr, pp. 2, 7.
1916 *Calymene planimarginata* Reed; Marr, pp. 191, 199, 200.
1933 *Calymene subdiademata* McCoy; Shirley, p. 65.
1934 *Calymene* cf. *planimarginata* Reed; King and Wilcockson, p. 10.
1936 *Diacalymene marginata* Shirley (*pars*), p. 416 (*pars*), pl. 29, fig. 20.
1948 *Calymene* (*Diacalymene*) *marginata* (Shirley); King and Williams, pp. 206, 210, pl. 16, fig. 2.
1959 *Diacalymene* cf. *marginata* Shirley; Dean, pp. 204, 208.
1962 *Diacalymene* cf. *marginata* Shirley; Dean, p. 116, pl. 13, fig. 13; pl. 14, fig. 11.
1966 *Diacalymene marginata* Shirley; Ingham, pp. 465–468, 484, 486, 489, 494, 497–498.
1977 *Calymene* (s.l.) cf. *marginata* (Shirley); Ingham, pp. 98–100, pl. 21, figs. 9–24.

Lectotype. Herein selected; SM A6806, internal mould of complete individual from the Applethwaite Formation (Cautleyan Stage, Zone 2), 'Coniston Water' (Pl. 9, fig. 9); figured by McCoy 1851, pl. 1F, fig. 10.

Material, localities, and horizon. This species has been collected from localities 9, 14–19, 22f, 41b in the middle and upper parts of the Applethwaite Formation (Cautleyan Stage, Zones 2 and 3) in the Lake District. It is particularly common on Moor Head, north of Applethwaite Common (localities 16–19), where it comprises almost 40 per cent of the trilobite fauna.

Emended diagnosis. A species of *Calymene* (s.l.) characterized by a strong posterior ridge on the preglabellar area which is separated from the anterior ridge by a gentle, posteriorly inclined flat surface; glabella bell-shaped, projecting only slightly in front of fixigena and bearing a small 2p lobe, half the diameter of the 1p lobe.

Discussion. McCoy (1851, pp. 166–167) based *C. subdiademata* on a number of specimens, but only figured two syntypes: a cranidium from the 'limestone of Leintwardine' and the complete, though distorted, specimen (SM A6806) from the Lake District. In his discussion of this species, Shirley (1933, p. 65) recommended that the name '*subdiademata*' be dropped, as one of the syntypes the cranidium from Leintwardinae, appears to be lost (this is confirmed by Dr. D. Price, Assistant Curator at the Sedgwick Museum) and the other specimen is distorted. As can be seen from Plate 9, fig. 9 the distortion has had little effect in diminishing any of the distinguishing characters of this species (as described by Ingham (1977, pp. 98–100) on conspecific material from the Cautley district). As further conspecific material has subsequently been collected from the same formation as the lectotype it would appear to be justifiable to retain McCoy's specific name.

Ingham (1977, p. 98) has called the northern England form *C.* (s.l.) cf. *marginata*. The holotype of *C.* (s.l.) *marginata* from the lower Drummuck Group (Cautleyan), Craighead Inlier, near Girvan is lost (Ingham 1977, pp. 98–99), but the illustrations by Shirley (1936, pl. 29, fig. 19) and of topotype material by Ingham (1977, pl. 21, figs. 7, 8) shows *C.* (s.l.) *marginata* to have a glabella which is relatively narrower posteriorly, a frontal lobe which has a more transverse anterior margin and which projects forward of the fixigena less than in *C.* (s.l.) *subdiademata*, and a 2p lobe larger relative to the 1p lobe. Shirley (1936, pl. 29, fig. 20) illustrated a specimen which he referred to '*Diacalymene marginata*' from the 'Calymene Beds (? Lower Bala), opposite Taythes Farm, near Cautley, Yorkshire'. Ingham (1977) has not discussed the taxonomic position of this specimen, but places it, along with the holotype of '*D.*' *marginata*, in the synonomy of *C.* (s.l.) cf. *marginata*. This Cautley specimen appears to belong to *C.* (s.l.) *subdiademata*.

Shirley (1933, p. 65) compared the lectotype of *C.* (s.l.) *subdiademata* to '*C.*' *quadrata* King as he thought the Lake District form like '*C.*' *quadrata*, possesses only twelve thoracic segments. One segment, however, is largely covered by the pygidium. Another complete specimen (Pl. 9, fig. 10) shows the presence of thirteen thoracic segments of typical calymemid form. Recently, Siveter (1977, p. 386) erected the genus *Sthenarocalymene* and included within it King's *C. quadrata*. *S. quadrata* belongs within the Flexicalymeninae and not the Calymeninae as it lacks fixigenal buttressing to the 2p lobe. The number of thoracic segments possessed by *Sthenarocalymene* is variable: the type species *S. lirella* Siveter (1976, p. 388) has thirteen, one more than *S. quadrata*.

C. (s.l.) *emicata* Ingham (1977, pp. 100–101, pl. 22, figs. 1–6) from the Rawtheyan Stage, Zone 5 of the Cautley district, has a longer, more inflated glabella than *C.* (s.l.) *subdiademata* and a more arched pregabellar area. *C.* (s.l.) *prolata* Ingham (1977, pp. 102–103, pl. 22, figs. 11–17) from the Cautleyan Stage, Zone 3 in the Cautley district, and *C.* (s.l.) *prolata* from the Torver and upper Applethwaite Formations (also Zone 3) of the Lake District can be distinguished from *C.* (s.l.) *subdiademata* by its more roll-like preglabellar area and glabella which projects strongly in front of the fixigenae. *C.* (s.l.) *drummuckensis* Reed (1906, p. 135, pl. 17, fig. 14; pl. 18, figs. 1-4) from the upper Drummuck Group, Girvan, has relatively larger 2p and 3p lobes than *C.* (s.l.) *subdiademata*, anterior keel of the anterior border set relatively higher than the posterior ridge, more transverse anterior margin of the frontal lobe and glabella which is narrower posteriorly. *C.* (s.l.) *crassa* (Shirley 1936, p. 416, pl. 29, figs. 21–23) from the lower Llandovery Gasworks Mudstone near Haverfordwest, has a longer, more convex glabella, which is relatively narrower posteriorly, larger 2p lobes and longer preglabellar area which has a less strongly developed posterior ridge than in *C.* (s.l.) *subdiademata* (Temple 1975, pl. 25, fig. 4).

Subfamily FLEXICALYMENINAE Siveter, 1976
Genus GRAVICALYMENE Shirley, 1936

Type species. *Gravicalymene convolva* Shirley, 1936, p. 409, pl. 29, figs. 16–18; from the Birdshill Limestone (Ashgill), Birdshill Quarry, near Llandeilo, south Wales.

Gravicalymene susi sp. nov.

Plate 10, figs. 1–13

?1845 *Calymene* n. sp.; Sedgwick, p. 455.
1851 *Calymene brevicapitata* Portlock; McCoy, p. 166, pl. 1F, fig. 6.
1865 *Calymene senaria* Conrad; Salter, p. 98.
1868 *Calymene brevi-capitata* Portlock; Nicholson, p. 53.
1873 *Calymene senaria* Conrad; Salter, p. 53.
1888 *Calymene brevicapitata* Portlock; Aveline, Hughes, and Strahan, p. 55.
1888 *Calymene senaria* Conrad; Aveline, Hughes, and Strahan, p. 55.
?1888 *Calymene* n. sp.; Aveline, Hughes, and Strahan, p. 55.
1892 *Calymene senaria* Conrad; Marr, p. 108.
1931 non *Calymene brevicapitata* Portlock; Shirley, p. 4.
1963*a* *Gravicalymene* cf. *praecox* (Bancroft); Dean, p. 55, pl. 1, fig. 11.
1977 *Gravicalymene deani* Ingham, p. 97 (*pars*).

Holotype. BM It8689, cranidium (Pl. 10, figs. 1–4), collected by W. T. Dean from the south-east bank of Stockdale Beck, just below the junction with Brow Gill (locality 4a); 25 m above the base of the Applethwaite Formation (Cauleyan Stage, Zone 2).

Material, localities, and horizons. This species commonly occurs (132 exuviae) in the lower-middle part of the Applethwaite Formation (Cautleyan Stage, Zone 2) in Longsleddale (localities 3, 4a, 4c, 4e, 4f, 9, 9a, 9b), Kentmere (localities 12a, 12b, 13, 14a, 14c, 14d), Pull Beck (locality 26a), and above Hussey Well Beck (locality 36). It occurs less commonly in the upper part of the Applethwaite Formation (Cautleyan Stage, Zone 3) (forty-nine exuviae from localities 16, 16a, 18a, 19 north of Applethwaite Common). The specimen figured by Dean (1963*a*, pl. 1, fig. 11) from the Stile End Formation (Cautleyan Stage, Zone 2) above Stockdale, Longsleddale (locality 8c), is placed in this species. A single cranidium is known from the High Pike Haw Formation (Cautleyan Stage, Zone 2) at High Pike Haw (locality 32).

Diagnosis. Glabella bearing relatively large 1p lobe and small 2p lobe and projecting beyond fixigena. Preglabellar area long (sag.), gently inclined posteriorly into deep furrow and rolled anteriorly. In plan, preglabellar area well rounded, laterally acuminate. Axial furrow broad and sinuous.

Description. Cephalon subtraphezoidal, broad. Glabella moderately vaulted; with low longitudinal convexity; strongly 'bell-shaped', 1p lobes being widely spaced, distance between their abaxial extremities being about 1·5 times that across 2p lobes and 1·9 times that across 3p lobes. 1p lobe bluntly subquadrate. 1p furrow narrow; deep laterally, wider and shallow adaxially where bifurcates, anterior branch faintly encircling 2p lobe, posterior branch curving back and shallowing as runs almost exsagittally to occipital furrow. 2p lobe small, subcircular, less than half diameter of 1p lobe. 2p furrow short, shallow, directed at 15° back from transverse line. 3p lobe is very small and subcircular, less than half diameter of 2p lobe. Frontal lobe short, occupying one-fifth glabellar length; gently rounded anteriorly. Occipital ring is widest medially, narrows distally; more strongly vaulted than glabella. Occipital furrow is narrow (sag.) medially, but broadens and deepens laterally. Preglabellar area is twice frontal lobe width (tr.); it is long, occupying almost one-quarter cranidial length (sag.); from deep, broad (sag.) furrow it slopes upwards at 45°, then curves over in broad roll (Pl. 10, figs. 3, 9, 10) and becomes directed postero-ventrally to rostral suture which is situated below level of furrow. In dorsal aspect border is gently convex forward; laterally acuminate towards anterior of facial suture. Axial furrow sinuous and broad (Pl. 10, fig. 2), abaxial wall gently rounded anteriorly; highest at eye lobe, which is prominently raised (Pl. 10, fig. 11) and situated opposite 2p lobe. Fixigena steeply declined to posterior border and flattens postero-laterally to bluntly rounded genal angle. Anterior branches of facial suture moderately convergent forward; posterior branch directed transversely initially from eye lobe, then recurved to bisect genal angle. Librigena triangular; bears prominent lateral border which narrows posteriorly; border furrow shallow.

Hypostome (Pl. 10, fig. 6) longer than broad; bears a moderately convex median body; median furrow faint, demarkating long (sag.) anterior lobe and short posterior lobe which is crescentic in outline. Posterior furrow bears a medially positioned depression. Lateral border furrow bears depression slightly posterior of lateral part of posterior lobe. Lateral border narrow, rolled, deeply embayed posterior to anterior wings. Posterior wings situated opposite posterior lobe. Posterior border is bilobed.

Rostral plate and thorax unknown. Pygidial axis bears five rings (Pl. 10, fig. 13); axis tapers posteriorly to broad, bluntly rounded tip; end piece occupies almost one-third length of axis; axial furrows become fainter posteriorly. Pleural area gently sloping except near border where it strongly declines; bears five pleurae and deep pleural furrows which terminate just short of smooth border. First four pleurae bear faint interpleural furrows which, close to axial furrow, are situated closer to posterior of pleura, but become medially positioned distally.

Discussion. The range of *Gravicalymene susi* (Cautleyan Stage, Zones 2 and 3) lies between that of *G. jugifera* Dean (1962, p. 116, pl. 13, figs. 9, 11; pl. 14, figs. 3, 4, 8, 9), which is restricted to Pusgillian strata in the Cross Fell Inlier (Dean 1962) and the Cautley district (Ingham 1977, p. 94), and *G. deani* Ingham (1977, p. 96, pl. 20, figs. 16, 17; pl. 21, figs. 1–6) which, though occurring rarely in Zone 2, is most common in Zone 3 of the Cautleyan Stage in the Cautley district. *G. susi* is also intermediate in morphology between *G. jugifera* and *G. deani*. It compares with the older *G. jugifera* in possessing a similarly inclined preglabellar area (though it is relatively longer in *G. susi* and has developed a thicker, rolled anterior part) and glabella with well-rounded frontal lobe which projects beyond the fixigena. The glabella of *G. susi*, however, is much more strongly 'bell-shaped', the 2p lobe being much smaller relative to the 1p lobe (compare Pl. 10, fig. 2 with Ingham 1977, pl. 20, fig. 16 and pl. 21, fig. 2).

Both *G. deani* and *G. susi* possess this strongly 'bell-shaped' glabella, though it is even more accentuated in *G. susi* due to the very small 2p lobes. However, the preglabellar area of *G. deani* is shorter, occupying only one-sixth of the cranidial length, more transverse anteriorly and is more strongly upturned and more broadly rolled. The glabella of *G. deani* does not project as far forward anteriorly as in *G. susi* and has a more transverse frontal lobe. *G. susi* can be particularly distinguished from *G. jugifera* and *G. deani* by its broad axial furrows.

It would seem likely that these three geographically related species reflect parts of a phylogenetic lineage. The preglabellar areas of both calymenid species which occurred during Zone 2 and in early Zone 3 in the southern Lake District, that is *Calymene* (s.l.) *subdiademata* and *G. susi*, are morphologically similar, their development probably reflecting the occupation of similar ecological niches. Consequently, the form of the preglabellar area must be afforded low taxonomic status in these calymenids (as suggested by Whittington 1971, p. 459) as it may be a homeomorphic feature. It would seem unwise to use it as the basis on which to postulate phylogenetic relationships as Ingham (1977, p. 97) considered may have been possible between *G. deani* and *G. hagani* Ross.

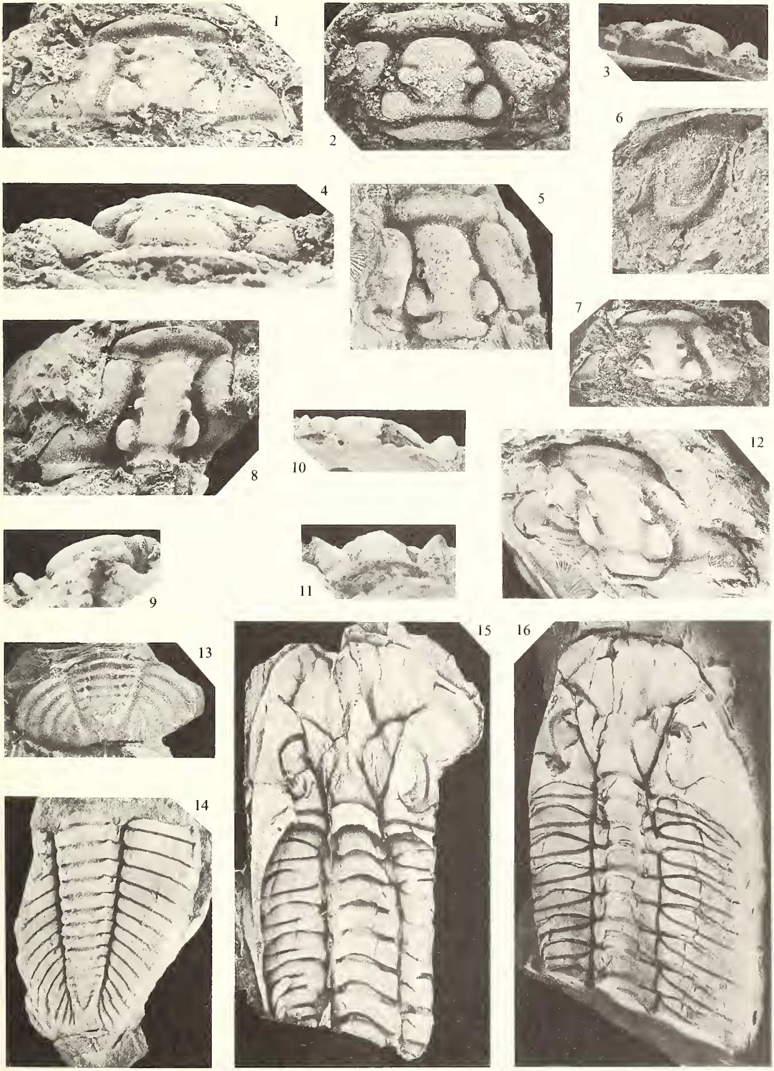
The type species of *Gravicalymene*, *G. convolva* Shirley (1936, p. 409, pl. 29, figs. 16–18) from the Birdshill Limestone (early Ashgill) of south Wales, has a much larger 2p lobe than *G. susi* and a more strongly upturned preglabellar area, rather like that of *G. deani*.

A specimen (Pl. 10, fig. 7) from 'Applethwaite Common' (probably SM A9569) referred to *C. brevicapitata* Portlock by McCoy (1851, p. 165, pl. 1F, fig. 6), subsequently referred to *C. senaria* Conrad by Salter (1865, p. 97), mentioned by Shirley (1931, p. 4) and then placed in *G. deani* by Ingham (1977, p. 97), is herein placed in *G. susi*.

EXPLANATION OF PLATE 10

Figs. 1–13. *Gravicalymene susi* sp. nov. Applethwaite Formation (Cautleyan Stage, Zones 2 and 3). 1–4, holotype, BM It8689, dorsal, 1, view of internal mould, and dorsal, 2, lateral, 3, and anterior, 4, views of cast of external mould of cranidium, from Brow Gill, Longsleddale (locality 4a), all ×2. 5, 10, 11, SM A98864, dorsal, 5, lateral, 10, and anterior, 11, views of cast of external mould of cranidium, from Garbourn Nook (locality 19), all ×2. 6, SM A98262, ventral view of internal mould of hypostome from same locality as 1, ×3. 7, SM A9569, dorsal view of internal mould of cranidium, from 'Applethwaite Common', ×2; also figured by McCoy (1851, pl. 1F, fig. 6). 8, 9, SM A98865, dorsal, 8, and lateral, 9, views of internal mould of cranidium, from same locality as 5, both ×2. 12, SM A98430, dorsal view of internal mould of cranidium, from Kentmere (locality 12a), ×1⅔. 13, SM A98261, dorsal view of internal mould of pygidium, from same locality as 1, ×2.

Figs. 14–16. *Toxochasmops marri* (Reed), Applethwaite Formation (Cautleyan Stage, Zone 2). 14, GSM Zs821, dorsal view of internal mould of pygidium, from 'Marshall's Park', Coniston, ×1⅓. 15, 16, holotype, SM A40168, dorsal views of cast of the external mould, 15, and internal mould, 16, from 'Applethwaite Common', ×1⅛; also figured by Reed (1894, pl. 7, figs. 1–3).



McNAMARA, Coniston trilobites

Family PTERYGOMETOPIDAE Reed, 1905
Subfamily CHASMOPINAE Pillet, 1954
Genus TOXOCHASMOPS gen. nov.

Type species. Trilobites extensus Boeck, 1838, p. 139, redescribed by Størmer (1941, p. 138, pl. 3, figs. 7–11); from 4bγ–δ, Gåsøkalven, Baerum, Norway.

Assigned species. T. extensus (Boeck 1838) [= *Chasmops macrourus* (Sjøgren 1851)], *T. wesenbergensis* (Schmidt 1881), *T. eichwaldi* (Schmidt 1881), *T. marri* (Reed 1894), *T. amphorus* (Salter 1864), *T. bisseti* (Reed 1906).

Diagnosis. Cephalic length half to almost two-thirds cephalic width. Anterior border moderately to strongly arched. Glabella gently convex; frontal lobe broad, and of low convexity, height/width ratio varying from 1 : 3·3 to 1 : 5. 3p glabellar lobe long, one-half glabellar length; 3p furrows sinuous, anteriorly divergent at 110°; 2p lobe extremely small. Central glabellar area narrow. Anterior branches of facial suture parallel to anteriorly divergent. Eye lobe moderate sized, set close to glabella. Hypostome long, median body almost twice as long as broad; posterior tongue long, one-quarter hypostome length. Pygidium long and narrow containing twelve to eighteen segments.

Discussion. Since its original conception, McCoy's (1849) genus *Chasmops* has been assigned twenty-nine species (Haller 1973, p. 729), although five of these have subsequently been assigned to other genera. The forms encompassed by the generic concept of *Chasmops* show a wide range of morphologies. Cephalic features which vary are cephalic shape, length, and convexity of frontal lobe, relative sizes of 2p and 3p glabellar lobes, size, elevation, and position of eye and orientation of anterior branch of the facial suture. The hypostome shows a large variation in length. The pygidium similarly shows a wide variation in length and number of segments. Future work will show the phylogenetic relationships between the various chasmopines. For the purpose of this work only the group containing '*C.*' *marri* has been separated into a new chasmopine genus.

The type species of *Chasmops*, *C. odini* (Eichwald), can be distinguished from all species of *Toxochasmops* by its smaller 3p lobe, which is less than half the glabellar length; more prominent 2p lobe; broader, shorter cephalon; more strongly convex frontal lobe; eye more laterally disposed, such that the anterior branches of the facial suture are anteriorly convergent; shorter hypostome; shorter, broader pygidium with fewer than ten segments.

Toxochasmops marri (Reed 1894)

Plate 10, figs. 1–8; Plate 11, figs. 15–17; text-fig. 5

?1845 *Asaphus Powisi* (Murchison); Sedgwick, p. 445.
?1846 *Phacops* (*Asaphus*) *Powisii* Murchison; Sedgwick, p. 238.
1851 *Chasmops odini*? (Eichwald); McCoy *in* Sedgwick and McCoy, p. 164.
1864 *Phacops* (*Chasmops*) *conophthalmus* Boeck?; Salter, p. 41.
1867 *Phacops conophthalmus* Boeck; Hughes, p. 354.
1868 *Phacops conophthalmus* Boeck; Nicholson, p. 54.
?1872 *Phacops* sp.; Aveline and Hughes, p. 5.
1873 *Phacops* (*Chasmops*) *macroura* (Sjøgren); Salter, p. 52.
1877 *Phacops* (*Chasmops*) *macroura* (Sjøgren); Harkness and Nicholson, p. 468.
1878 *Phacops* (*Chasmops*) *macroura* (Sjøgren); Marr, pp. 871, 873.
1878 *Phacops* (*Chasmops*) *conophthalmus* Boeck; Marr, pp. 871, 873.
1888 *Chasmops odini*? (Eichwald); Aveline, Hughes, and Strahan, p. 55.

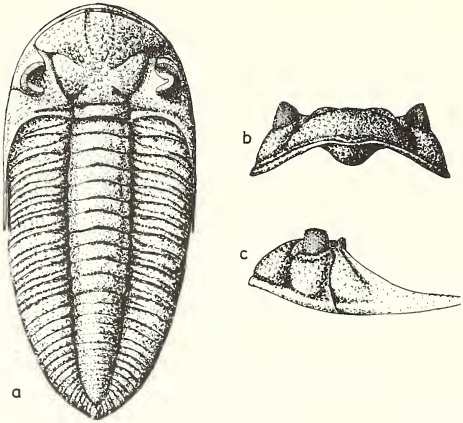
1888 *Phacops conophthalmus* Boeck; Aveline, Hughes, and Strahan, p. 55.
1888 *Phacops macroura* (Sjøgren); Aveline, Hughes, and Strahan, p. 55.
1892 *Phacops* cf. *eichwaldi* Schmidt; Marr, pp. 99, 109.
1892 *Phacops* (*Chasmops*) sp.; Marr, p. 103.
1892 *Phacops* cf. *brevispina* Schmidt; Marr, p. 109.
1894 *Phacops* (*Chasmops*) *marri* Reed, pp. 241–246, pl. 7, figs. 1–3.
1906 *Phacops marri* Reed; Reed, p. 159.
1913 *Phacops* (*Chasmops*) sp.; Marr, p. 9.
1916 *Phacops* (*Chasmops*) *marri* Reed; Marr, pp. 191, 195, 197, 199, 200.
?1934 *Chasmops* sp.; King and Wilcockson, p. 11.
1959 *Chasmops* cf. *marri* (Reed); Dean, p. 218, Table 3.
1963*a* *Phacops* (*Chasmops*) *marri* Reed; Dean, p. 50.
1963*a* *Chasmops* cf. *extensa* (Boeck); Dean, p. 54, pl. 1, figs. 1, 2, 5, 10.
1966 *Chasmops marri* (Reed); Ingham, pp. 466–468, 484–486, 489, 498–499.
1968 *Chasmops* sp.; Whittington, p. 123.
1970 *Chasmops*; Ingham and Wright, p. 234.
1973 *Chasmops marry* (*sic*) (Reed); Haller, p. 729.
1973 *Chasmops* sp.; Price, pp. 233–234, Tables 2 and 3.

Holotype. SM A40168, an articulated specimen (Pl. 10, figs. 15, 16) which lacks the posterior three thoracic segments and the pygidium; from the Applethwaite Formation of 'Applethwaite Common', figured by Reed 1894, pl. 7, figs. 1–3.

Material, localities, and horizons. This species occurs very commonly in the Stile End Formation (Cautleyan Stage, Zone 2) comprising 40·7 per cent of the trilobite fauna; disarticulated specimens have been collected from the quarries above Stockdale Farm (localities 7a, 7b, 8a, 8b, 8c), and behind Kentmere Hall, Kentmere (locality 38). It comprises 28 per cent of the trilobite fauna of the High Pike Haw Formation (Cautleyan Stage, Zone 2), specimens principally coming from locality 32 at High Pike Haw. It is less common in the calcareous mudstones of the Applethwaite Formation (Cautleyan Stage, Zones 2 and 3), thirty-five specimens from Longsleddale (localities 3, 4c, 4e, 4f, 9b), Kentmere (locality 14a), Moor Head (locality 16b), Garbourn Nook (locality 19), Torver (localities 23f, 43), comprising only 5·2 per cent of the trilobite fauna.

Emended diagnosis. Anterior border of cephalon with median downward flexure. Frontal lobe very broad and with low convexity. Orle furrow set close to anterior border furrow. Eye lobe set close to glabella such that exsagittal line passing lateral extremity of frontal lobe passes through mid-point of eye. Pygidium with sixteen axial rings and fourteen pleurae.

Description. Cephalon sub-semicircular; the holotype shows an exaggerated length/breadth ration caused by distortion. Less distorted material suggests the cephalon may have been three-fifths as long as broad. Glabella is almost flat posteriorly to anterior tips of 3p lobe, then it declines anteriorly at about 45°. Frontal lobe slopes laterally at about 30° below the horizontal. Glabella broadest anteriorly across frontal lobe, maximum width being two-thirds cephalic width; narrowest across 2p lobes where it is one-quarter maximum glabellar width. Frontal lobe occupies two-thirds length of glabella; it is broad, ratio to maximum across 3p lobes being 1 : 0·6; it has low convexity with a height to breadth ratio of about 1 : 4·5. An exsagittal line passing lateral extremity of frontal lobe would pass through centre of eye lobe (Pl. 10, fig. 3). 3p furrow curves sinuously around 3p lobe, abaxially being directed inwards transversely before curving backwards at 45° to a transverse line. Neither of the anterior two pairs of glabellar furrows is transglabellar, but stop such that a central glabellar area remains between 3p lobes. This area is depressed below level of rest of glabella and is one-fifth width of frontal lobe. 3p lobe is large and triangular; its maximum length (exsag.) is two-fifths length of glabella. Posteriorly 3p lobe extends past small 1p and 2p lobes; it reaches a little farther forward than anterior of eye lobe. 2p lobe is very small (Pl. 10, figs. 3, 5). 2p furrow exists only as inner part of deep furrow which bounds posterior of 3p lobe. This furrow bifurcates adaxially, one branch, the 2p furrow, extending around anterior of 2p lobe, the other, the 1p furrow running around anterior of 1p lobe. Deep coexistent 1p and 2p furrow is directed forwards adaxially at 45°. 1p lobe a little larger than 2p lobe. Occipital ring occupies two-sevenths width of cephalon, and is of constant length (sag. and exsag.), occupying one-seventh length of cranidium. Occipital furrow narrow (sag. and exsag.), transverse and deep.



TEXT-FIG. 5. Reconstructions of *Toxochasmops marri* (Reed); (*a*) dorsal view; (*b*) anterior view; (*c*) lateral view of cephalon, approximately × 1.

Axial furrows diverge forward at 70° and follow a sinuous course; rise anteriorly from posterior border, then narrow and shallow opposite 3p lobes before plunging steeply to anterior border. Preglabellar furrow very shallow and bounded anteriorly by a thick convex border. Anterior view of cephalon shows that border rises gradually until it is level with frontal lobe. It then becomes horizontal but dips down medially. Orle furrow (Pl. 11, fig. 7) runs close to and parallel with preglabellar furrow within frontal lobe. It is shallowest antero-laterally and deepest medially, where it forms two pairs of prominent pits from which an oval of small auxiliary impressions extends back over centre of frontal lobe. Eye lobe strongly crescentic, set close to glabella and occupies almost one-quarter cranidial length; anterior margin in line with anterior part of 3p lobe, posterior in line with posterior of 3p lobe. Eye surface bears thirty dorso-ventral files of lenses with a maximum of sixteen and a minimum of four lenses in each file. A deep, broad furrow runs around base of eye. Posterior branch of facial suture is directed outwards and slightly forwards then runs in a broad, shallow furrow in a gentle, convex-forward curve to lateral border, which it intersects in line with posterior of 3p lobe. Anterior branches of facial sutures diverge anteriorly at 60°; they do not intersect anterior border but run transversely in preglabellar furrow. Fixigena is narrow (tr.) anteriorly, widens past eye lobe, then narrows at first posteriorly before greatly widening towards posterior border; steeply declines laterally. Posterior border is a narrow (exsag.), raised rim adaxially, which widens and flattens towards genal angle. As it joins lateral border it becomes vertically orientated and sweeps back as long, gradually narrowing genal spine which reaches to posterior of thorax. Posterior border furrow is narrow and deep adaxially; shallows and broadens abaxially before degenerating as it approaches faint lateral border furrow which similarly shallows towards genal angle. Librigena is gently convex; lateral border is broad, raised, rolled; bounded by wide, shallow furrow. Glabella is covered by many large tubercles with intervening smaller, adventious ones (Pl. 11, fig. 5). There is a general diminution in tubercle size laterally. Tubercles are also present on fixigena inside eye lobe.

Middle body of hypostome (Pl. 11, fig. 2) is widest opposite wide, triangular wings which extend horizontally antero-laterally, but curve downwards through almost a right angle posteriorly. Wing process is very prominent. Shoulder behind wing extends posteriorly to two-thirds hypostomal length. A deep middle furrow begins opposite shoulder and extends inwards and backwards; behind this a crescentic lobe is defined which occupies one-quarter hypostomal length.

Thorax (Pl. 10, figs. 15, 16; Pl. 11, fig. 1) consists of eleven segments. Axis occupies nearly one-third of thoracic width and is strongly vaulted. Axial furrow is well defined, deep, and narrow. Pleurae almost flat adaxially, but at fulcrum, which is set at three-quarters pleural width, they sharply decline; bluntly and abruptly terminated; bear deep, diagonal pleural furrow. Anterior pleural band narrow (exsag.) adaxially, broadens abaxially at first, then narrows close to fulcrum.

Pygidium (Pl. 10, fig. 14; Pl. 11, figs. 1, 8) bears up to sixteen axial rings and fourteen pleurae, the last two axial furrows being very faint. Axis tapers gently posteriorly, its maximum width occupying nearly one-third anterior width of pygidium; it occupies four-fifths length of pygidium, the post-axial region sloping downwards at first and bearing faint longitudinal pleural furrows before becoming smooth and upturned. Axial furrow is deep and narrow, becoming shallower at tip of axis. Interpleural furrows are deep and narrow adaxially becoming quite faint close to border; posterior five or six pairs, in fact, fail to reach border and become increasingly sinuous. Anteriorly interpleural furrows are straight and directed almost transversely, but farther back become increasingly posteriorly directed, recurving close to lateral border, last few pairs running almost parallel to axis. Anterior six pleurae bear faint pleural furrows which become more poorly developed posteriorly.

Discussion. Dean (1963*a*, p. 54) referred the species of *Toxochasmops* from the Stile End Formation to '*Chasmops* cf. *extensa*'. Further collecting by the author has revealed that this form is the same as that from the overlying Applethwaite Formation, *T. marri*. Dean regarded the Stile End Formation as being Actonian in age, but it has recently been shown (McNamara *in press*) to be early Cautleyan (Zone 2) in age, like the lower and middle parts of Applethwaite Formation. *T. extensus* can be distinguished from *T. marri* in having the eye lobe positioned farther from the glabella, a narrower frontal lobe and a pygidium with a greater number of segments. In addition the glabellar convexity is greater than in *T. marri*.

The two British species most similar to *T. marri* are *T. amphorus* (Salter 1864, p. 42, pl. 4, fig. 16) from the Crûg Limestone, south Wales, and *T. bisseti* (Reed 1906, p. 157, pl. 20, fig. 1–3) from the upper Drummuck Group, Thraive Glen, Girvan. *T. amphorus* was erected by Salter on a pygidium. Although having a similar number of segments as *T. marri* this specimen has an axis which is particularly broad anteriorly and tapers strongly posteriorly. It is very stongly convex, the distal parts of the pleurae being vertically inclined. A cranidium (SM A42810) from the same horizon and locality as the holotype has been discovered in the Sedgwick Museum, Cambridge. It is similar to the cephalon of *T. marri*, but lacks the pronounced median flexure of the anterior border. In addition the orle furrow is not set as close to the anterior border furrow and the 3p lobe is relatively longer. *T. bisseti* also lacks the median flexure of the anterior border, has the eye lobe set closer to the glabella, and has a narrower frontal lobe and a shorter pygidium with thirteen axial rings and fourteen pleurae.

The two other species which show a close resemblance to *T. marri* are *T. wesenbergensis* (Schmidt 1881, pl. 4, figs. 10–12; pl. 5, figs. 1–7) from the Rakvere Stage (E) and *T. eichwaldi* (Schmidt 1881, pl. 5, figs. 8–10) from the Nabala (F_1a), Vormsi (F_1b), Pirgu (F_1c), and rarely the Porkuni (F_2) stages (Rõõmusoks 1953, p. 412) of Estonia. The eye lobe of *T. wesenbergensis* is set farther from the glabella than in *T. marri*, whilst in *T. eichwaldi* the eye lobe is closer to the glabella and positioned more posteriorly. Neither of these species has the median flexure of the anterior border, whilst *T. wesenbergensis* has two fewer pygidial axial rings than *T. marri*.

In addition to its occurrence in the Lake District, *T. marri* also occurs in the Cautley district where it is restricted to the Cautleyan Stages, Zones 1–3 (Ingham

1966, p. 486). Material from the Dholhir Beds of the Berwyns, north Wales (Whittington 1968, p. 121) has been examined and can be referred to *T. marri* as can '*Chasmops* sp.' from the Sholeshook Limestone, south Wales, listed by Price (1973, tables 2 and 3).

Family ODONTOPLEURIDAE Burmeister, 1843
Subfamily ODONTOPLEURINAE Burmeister, 1843
Genus ACIDASPIS Murchison, 1839

Type species. By monotypy; *Acidaspis brightii* Murchison, 1839, p. 658, pl. 14, fig. 15; from the Wenlock Limestone.

Acidaspis magnospina Stubblefield, 1928

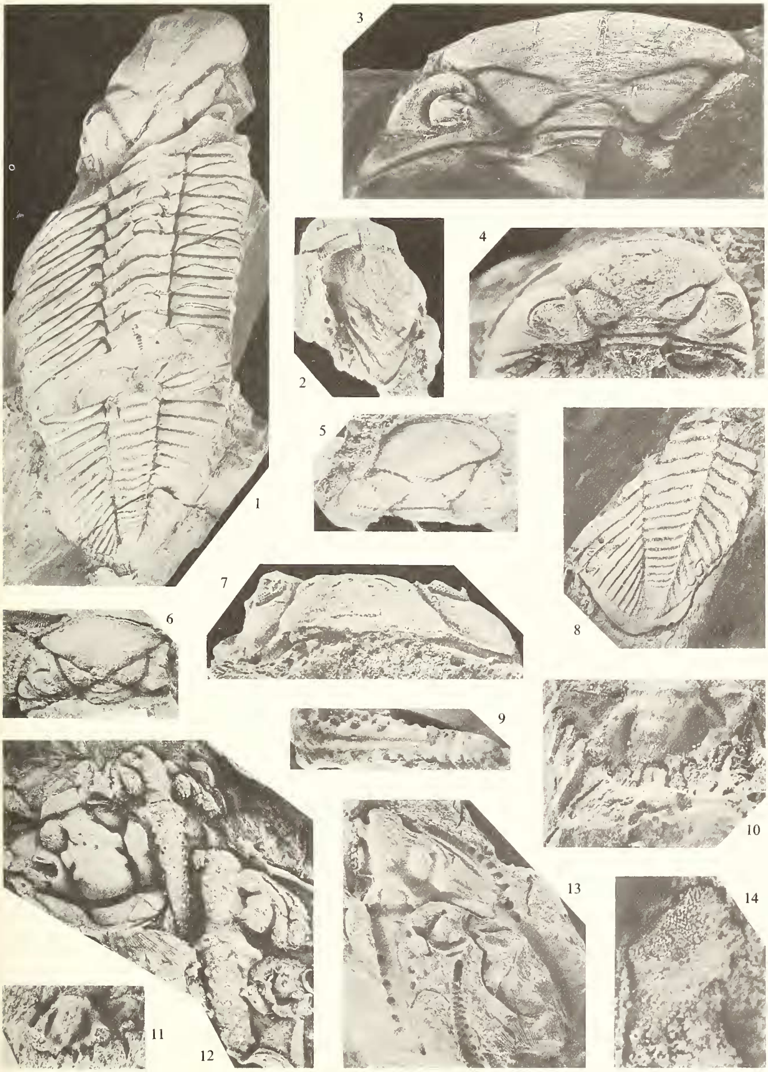
Plate 11, figs. 9–14; Plate 12, figs. 1–9; text-fig. 6

1888 *Acidaspis Brightii* Murchison; Aveline, Hughes, and Strahan, p. 55.
1891 *Acidaspis* n. sp.; Nicholson and Marr, p. 511.
1892 *Acidaspis* n. sp.; Marr, p. 108.
1928 *Acidaspis magnospina* Stubblefield, pp. 428–433, p. 14, figs. 1–6.
1933 *Acidaspis magnospina* Stubblefield; Warburg, pp. 15–16.
1937 *Acidaspis magnospina* Stubblefield; Opik, p. 43.
1949 *Acidaspis magnispina* (*sic*) Stubblefield; Prantl and Přibyl, pp. 26, 141.
1956 *Acidaspis magnospina* Stubblefield; Whittington, p. 513.
1962 *Acidaspis magnospina* Stubblefield; Dean, p. 50.
1963*a* *Acidaspis magnospina* Stubblefield; Dean, p. 123.
1966 *Acidaspis magnospina* Stubblefield; Ingham, pp. 465, 467–468, 486.
1967 *Acidaspis magnospina* Stubblefield; Ross, p. B17.
1970 *Acidaspis* sp.; Ingham and Wright, p. 237.
1973 *Acidaspis* cf. *magnospina* Stubblefield; Price, p. 244.

EXPLANATION OF PLATE 11

Figs. 1–8. *Toxochasmops marri* (Reed), Applethwaite Formation (Cautleyan Stage, Zones 2 (4, 7) and 3 (1, 2, 5)), Stile End Formation (Cautleyan Stage, Zone 2) (3, 8), High Pike Haw Formation (Cautleyan Stage, Zone 2) (6). 1, 2, SM A98867, dorsal view of internal mould of articulated specimen which lacks only its librigenae, 1, and ventral view showing the hypostome in position, 2, from Garbourn Nook (locality 19), both ×1. 3, SM A98111, dorsal view of internal mould of cephalon, from Stockdale, Longsleddale (locality 7b), ×1½. 4, 7, BM It8678, dorsal, 4, and anterior, 7, views of internal mould of cephalon, from Brow Gill, Longsleddale (locality 4a), both ×2. 5, SM A98857, dorsal view of cast of external mould of incomplete cranidium, from same locality as 1, ×2. 6, SM A98245, dorsal view of internal mould, from High Pike Haw (locality 32), ×1¾. 8, SM A98114, dorsal view of internal mould of pygidium, from same locality as 3, ×1⅓.

Figs. 9–14. *Acidaspis magnospina* Stubblefield, Applethwaite Formation (Cautleyan Stage, Zone 3); all from Garbourn Nook (locality 19). 9, SM A98783, cast of external mould of ventral surface of occipital spine showing the median groove and distribution of tubercles, ×2½. 10, SM A98786, dorsal view of internal mould of pygidium, ×3½. 11, SM A98839, dorsal view of internal mould of pygidium, ×7. 12, 13, BM In27066, fig. 12 showing Stubblefield's (1928, pl. 14, figs. 1, 2) holotype and a paratype; the specimen lower right is the holotype; the specimens are resting against a cranidium of *Calymene subdiademata*; fig. 12 is the cast of the external mould; fig. 13 shows a dorsal view of the internal mould of the holotype; both figs. ×2½. 14, SM A98772, internal view of the upper part of the librigena showing the eye surface, ×12.

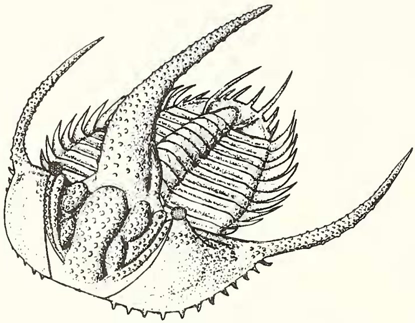


McNAMARA, Coniston trilobites

Holotype. BM In27066, incomplete cephalon (Pl. 11, figs. 12, 13) from the Applethwaite Formation (Cautleyan Stage, Zone 3), Garbourn Nook (locality 19); figured by Stubblefield 1928, pl. 14, figs. 1, 2.

Material, localities, and horizon. Twenty-five disarticulated specimens are known from the same area as the type specimens (Applethwaite Common, localities 16a, 19), those from locality 19 being topotype material; the localities are in the upper part of the Applethwaite Formation (Cautleyan Stage, Zone 3). One specimen has been collected from Stunfel Howe (locality 14c).

Emended diagnosis. Glabella with ill-defined 3p lobe and narrow, well-defined central glabellar area. Librigenal and occipital spines very long, twice cephalic length. Hypostome with poorly developed posterior lobe and well-developed anterior wings. Pygidium bearing six pairs of border spines, three pairs being anterior to major pair.



TEXT-FIG. 6. Reconstruction of *Acidaspis magnospina* Stubblefield; oblique antero-lateral view, approximately × 4.

Description. Cephalon sub-oval, bearing three posteriorly directed spines, two librigenal, one occipital, of equal length; length of spines nearly three times glabellar length (Pl. 12, figs. 1, 2) extending back to posterior of pygidium. Cranidium semicircular and strongly convex. Glabella widest posteriorly; five-eighths maximum cranidial width; tapers gently forward from posterior then, anterior to 2p lobe, tapers more strongly forward. Transverse width, posteriorly, is a little greater than sagittal length. Glabellar furrows delineate rectangular central glabellar area whose sagittal length is almost three times transverse width; strongly convex transversely, whilst longitudinally it curves forwards and downwards through an arc of 75° to terminate against short (sag.) shallow preglabellar furrow which is bounded anteriorly by gently inclined border. 1p lobe oval, with long axis set at 20° to sagittal line; occupies one-half length of glabella; 1p furrow deep; from axial furrow directed postero-medially from axial furrow at 45°, then recurves to run back exsagittally to occipital furrow, thus isolating glabellar lobe from central glabellar area. 2p lobe sub-oval and occupies just less than half area of 1p lobe. 2p furrow runs postero-medially from axial furrow at 20° to sagittal line, then recurves to run exsagittally to join 1p furrow genuflection. A very faint swelling on side of glabella a little in front of 2p lobe is indicative of a 3p lobe (Pl. 12, fig. 3). Occipital furrow broad (sag.) and shallow; declines steeply laterally, curving backwards, as it is met by 1p furrow, to meet posterior end of axial furrow in a depression behind 1p lobe. Within this broad depression is a raised occipital lobe. Occipital ring developed posteriorly into a long, stout spine (Pl. 11, fig. 12). Anteriorly occipital area is broad, extending laterally almost to behind eye lobe; rapidly narrows posteriorly to half this width, then continues as long, stout, hollow spine which gradually tapers posteriorly and occupies three times length of glabella, extending almost to posterior of pygidium. Initially it rises steeply from occipital furrow, at 60° to horizontal, to twice cranidial height; then, at one-third its length from occipital furrow it becomes horizontally orientated (Pl. 12, fig. 1). Ventral surface of spine rises more shallowly than dorsal surface initially; it then steepens before arching back posteriorly. This results in the development on internal moulds, where the spine is missing, of Stubblefield's (1928, p. 429) transverse 'post-occipital line' (Pl. 12, fig. 9). In transverse cross-section, spine is 'kidney-shaped', dorsal surface being strongly convex, whilst ventral surface carries a medially positioned, dorsally directed groove (Pl. 11, fig. 9). Ventro-laterally twelve prominent, large tubercles are present (Pl. 11, fig. 9; Pl. 12, fig. 1) which are arranged such that anterior four pairs are equally spaced and next two pairs set close together, this sequence being repeated.

Axial furrow deep posteriorly but shallows as it rises out of occipital furrow, becoming very shallow and narrow opposite 2p lobe; deepend anterior to this. Fixigena comprises an inner ridge (which runs parallel to axial furrow and degenerates opposite 2p furrow) and an outer, narrower ridge (the eye ridge) which parallels inner ridge, but is longer, curving inwards anteriorly to abut against glabella in front of 2p lobe (Pl. 12, fig. 3). Inner ridge carries three rows of tubercles posteriorly which merge to form a single row anteriorly; eye ridge bears a single, sinuous row of about eight tubercles (Pl. 12, fig. 3). Eye lobe set far back opposite posterior of 1p lobe (Pl. 12, fig. 2). Anterior branches of facial suture almost parallel close to eye, but become increasingly more convergent anteriorly; meet anterior border in front of 2p lobe. Area of fixigena between facial suture and eye ridge develops as an anteriorly widening depression which bears an apodemal pit antero-lateral to 2p lobe; it then shallows into anterior border. Posterior branch of facial suture runs almost transversely for a short distance from eye lobe before curving postero-laterally to meet posterior border close to inner part of librigenal spine (Pl. 12, fig. 6). Librigena bordered by raised, narrow, convex rim that bears eleven border denticles which lengthen and become more horizontally orientated posteriorly. Lateral border furrow is broad and shallow. Librigena narrows upwards towards eye; holochroal eye surface is semi-cylindrical, and domed dorsally (Pl. 11, fig. 13). Librigena bears a long, curved slender spine (Pl. 11, fig. 13; Pl. 12, figs. 2, 8, 9) which reaches as far back as occipital spine. In addition to occurrence of tubercles on fixigena, tubercles are also present on central glabellar area and glabellar lobes, dorsal surface of occipital spine and dorsal surface of librigenal spine; these tubercles are arranged irregularly. A further cluster of large tubercles is set on librigena below eye. A prominent swelling is present on occipital ring anterior to development of occipital spine.

Hypostome (Pl. 12, fig. 4) slightly wider (tr.) than long (sag.). Middle body moderately convex, subcircular in outline. Posterior lobe crescentic; ill-defined anteriorly by faint furrow. Lateral and posterior furrows deep, wide. Posterior border a little inflated laterally. Lateral border narrows anteriorly before widening into short anterior wings; acuminate postero-laterally. Anterior border is straight.

Total number of thoracic segments unknown, though it may, like all other species of *Acidaspis*, have possessed ten. One incomplete specimen (SM A43418; Pl. 12, fig. 5) bearing seven displaced thoracic segments, shows the axial rings to curve forwards laterally as they decline and thicken into axial furrow. Anterior two segments bear short (tr.) pleurae which only extend as far as inner part of librigenal spine. Width (tr.) of pleurae from axial furrow to fulcrum in succeeding pleurae is far greater than in anterior two pairs. Pleurae bear short lateral spines. Broad (exsag.) pleural furrow separates short convex anterior band from longer convex posterior band.

Pygidium (Pl. 11, figs. 10, 11) bears a triangular axis which carries a large, convex anterior ring and a smaller, lower, posterior ring which tapers back to a small, flat posterior plate that reaches almost to posterior border. Anterior ring extends laterally into a pleural ridge which curves posterially to run at 25° from the sagittal line. It continues across border, extending back as a long, stout spine which is three times as long as the pygidium. Semicircular border bears three spines antero-lateral to macrospine, and two postero-laterally; they all extend at about 25° from the sagittal line. Thus border bears a total of twelve spines. Macrospine carries a single, small tubercle close to its junction with axial ring; otherwise pygidial surface is smooth.

Discussion. A. magnospina Stubblefield is the oldest-known representative of this genus in Britain. The only other British Ordovician species is *A. asteroidea* Reed (1914, p. 31, pl. 5, figs. 3–7) from the upper Drummuck Group, Girvan. This species differs from *A. magnospina* in having a shorter occipital spine and bearing one less pair of pygidial spines. Two species of *Acidaspis* of Ordovician age occur in Estonia: *A. viruana* (Öpik 1937, p. 43, pl. 5, fig. 1; Bruton 1968, p. 296, figs. 8, 9?) and

A. aviensis Bruton (1968*a*, p. 299, figs. 11, 12). *A. viruana* is probably a little older than *A. magnospina*, occurring in the Rakvere Stage (E); it differs in possessing a shorter occipital spine, more prominent 3p lobe, and broader central glabellar area. The pygidium which Bruton (1968*a*, figs. 9, 10) referred to this species has one fewer pair of border spines anterior to the major pair. *A. aviensis* from the Porkuni Stage (F_2), is a little younger than *A. magnospina*; it lacks an occipital spine (Bruton 1968*a*, fig. 11), has a prominent 3p lobe, this being absent or minute in the British species, and a 'bicomposite' 1p lobe.

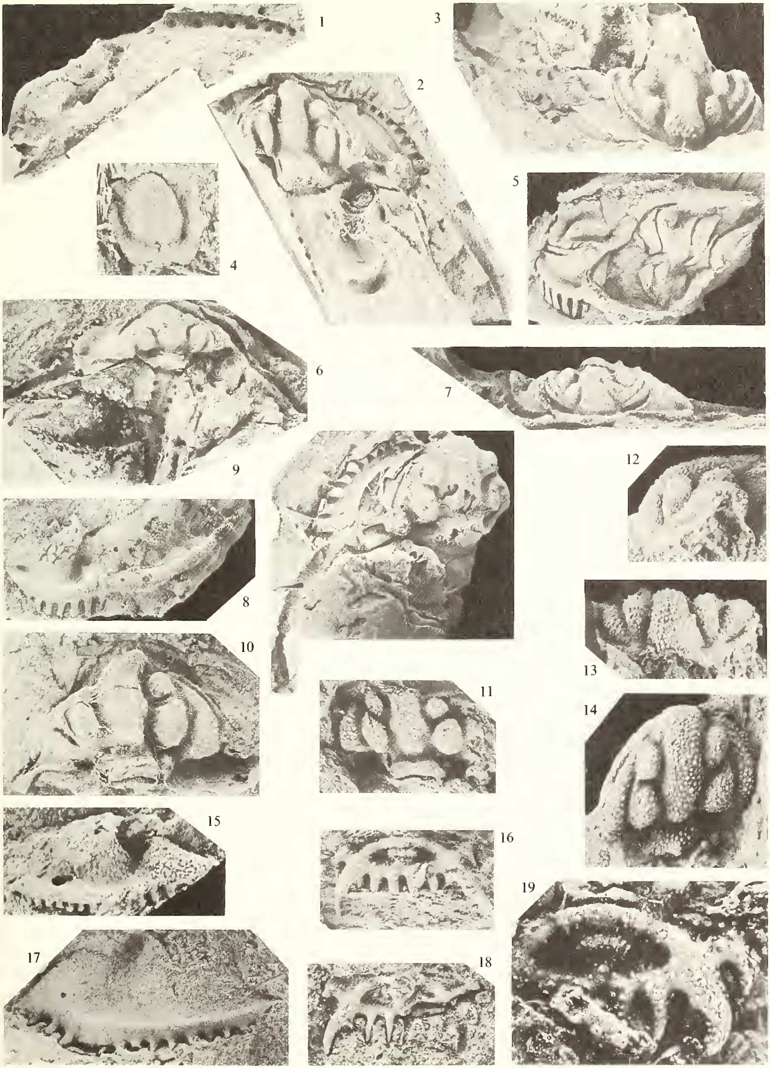
A. cincinnatiensis Meek (1873), redescribed by Whittington (1956, p. 512, pl. 58, figs. 9–11, 13, 14; pl. 59, figs. 1–3, 6, 9–11), is a little older than *A. magnospina*, occurring in upper Trentonian to Maysville strata. It has shorter cephalic spines than *A. magnospina*, prominent 3p lobe, and greater number of pygidial spines. The hypostome of *A. cincinnatiensis* has a more well-defined posterior lobe, shorter anterior wings, and lateral projection of the lateral border set more anteriorly. Ross (1967, p. B17, pl. 5, figs. 19, 20) mentions a species of *Acidaspis* from Kentucky which was approximately contemporaneous with *A. magnospina*. This species also appears to lack a 3p lobe, but, as Ross states, it differs from *A. magnospina* in having a shorter occipital spine.

A. magnospina also occurs in the Cautley district (Ingham 1966), where it ranges from the Pusgillian Stage to Zone 2 of the Cautleyan Stage, or even possibly as high as Zone 4. Price (1973) records *A.* cf. *magnospina* from the Birdshill Limestone in south Wales. These specimens have been seen and are similar to the type material. *A. magnospina* has also been recorded from the Dufton Shales (Dean 1962) of higher Pusgillian age in the Cross Fell Inlier. It appears to be restricted to early Zone 3 in the Lake District.

EXPLANATION OF PLATE 12

Figs. 1–9. *Acidaspis magnospina* Stubblefield, Applethwaite Formation (Cautleyan Stage, Zone 3); all from Garbourn Nook (locality 19). 1, 2, 3, SM A98768, lateral, 1, dorsal, 2, and lateral, 3, views of internal mould of incomplete cephalon, all ×3. 4, SM A98843, ventral view of internal mould of hypostome, ×4. 5, SM A43418, dorso-lateral view of cast of external mould of incomplete, articulated individual, ×2. 6, 7, SM A98878, dorsal, 6, and anterior, 7, views of internal mould of cephalon, ×3. 8, SM A98787, lateral view of cast of external mould of librigena, ×3½. 9, BM In27067, dorsal view of internal mould of incomplete cephalon, ×2.

Figs. 10–19. *Primaspis bucculenta* sp. nov. Torver Formation (10–14, 17–19) and upper Applethwaite Formation (16), both Cautleyan Stage, Zone 3; Staurocephalus Limestone (15). 10, SM A43127, dorsal view of internal mould of cranidium, from Old Pits Beck (locality 35b), ×4. 11, SM A43126, dorsal view of internal mould of incomplete cranidium, from same locality as 12, ×8. 12, 13, 14, holotype, SM A98931, lateral, 12, anterior, 13, and dorsal, 14, views of cast of external mould of cranidium, from Willy Scrow (locality 25a), ×6. 15, SM A32845b, lateral view of cast of external mould of librigena, from Swindale, Knock, ×6. 16, SM A98713, dorsal view of cast of external mould of pygidium, from Moor Head, Troutbeck (locality 18a), ×6. 17, SM A43168, lateral view of internal mould of librigena, from same locality as 12, ×6. 18, SM A43120, dorsal view of internal mould of pygidium, from same locality as 12, ×6. 19, SM A43227, dorsal view of cast of external mould of pygidium, from same locality as 12, ×6.



McNAMARA, Coniston trilobites

Genus PRIMASPIS R. and E. Richter, 1917

Type species. Odontopleura primordialis Barrande, 1846, from the Libeň Formation, Dědu Berouna, Bohemia, figured by Barrande 1852, pl. 37, fig. 14 and refigured by Bruton 1968*b*, pl. 1, fig. 9.

Primaspis bucculenta sp. nov.

Plate 12, figs. 10–19

1891 *Staurocephalus globiceps* Portlock; Nicholson and Marr, p. 505.
1913 *Acidaspis* cf. *dalecarlica* Törnquist; Marr, p. 7.
1916 *Acidaspis asteroidea* Reed?; Marr, p. 199.
1916 *Acidaspis* sp. nov.; Marr, p. 199.
1916 *Staurocephalus murchisoni* Barrande?; Marr, p. 199.
1948 *Acidaspis* cf. *asteroidea* Reed; King and Williams, p. 210, pl. 16, fig. 4.
?1966 *Primaspis* cf. *dalecarlica* (Törnquist); Ingham, pp. 466–467, 470, 486, 497–502.
1967 '*Acidaspis* cf. *dalecarlica*' (Törnquist); Bruton, p. 7.
1967 *Primaspis evoluta* (Törnquist); Bruton, p. 7 (*pars*).

Holotype. SM A98931 (Pl. 12, fig. 1), cranidium from the Torver Formation (Cautleyan Stage, Zone 3), the base of Willy Scrow (locality 25a).

Material, localities, and horizons. Twenty-four disarticulated cranidia, librigenae, and pygidia are known; all, except for three pygidia and one cranidium, are from the Torver Formation (Cautleyan Stage, Zone 3) from the region of Torver Beck (localities 21e, 23e, 35b) and from the base of Willy Scrow (locality 25a). Of the other three specimens, two were found north of Applethwaite Common (locality 18a), near the top of the Applethwaite Formation (Cautleyan Stage, Zone 3) whilst a cranidium was found by Dr. J. K. Ingham at the same horizon at Kentmere (locality 41b). The species is thus restricted to Zone 3 in the Lake District.

Diagnosis. Broad fixigena and basal glabellar lobe, each as wide as central glabellar area posteriorly. 2p lobe two-thirds size of 1p lobe. Librigenal spine strongly swollen where joins border. Pygidium bears ten spines; only one pair antero-lateral to macrospine; pygidium three times as wide as long.

Description. Cranidium wider than long; strongly convex. Glabella probably slightly wider than long, being widest across 1p lobes, then gently narrowing to 2p lobes, anterior to which it rapidly narrows. 1p lobe oval, with long axis diverging forwards from exsagittal line at 20° (Pl. 12, figs. 10, 11); occupies one-third posterior glabellar width and a little under one-half glabellar length; occupies same width as central glabellar area. 1p furrow directed initially postero-medially at 30° from transverse line, then curves back and runs exsagittally to occipital furrow, thus isolating 1p lobe from central glabellar area. 2p lobe subcircular, occupying about two-thirds area occupied by 1p lobe. 2p furrow directed postero-medially more acutely than 1p furrow, at about 45°, then, adaxially, runs exsagittally to meet inner part of 1p furrow. Isolated central glabellar area approximates to a rectangle but narrows opposite glabellar lobes (Pl. 12, fig. 11). At its widest it is only just as wide as 1p lobe, at its narrowest as wide as 2p lobe. 3p lobe very small (Pl. 12, fig. 14), elongate, with its long axis set close to exsagittal line. Frontal lobe very short, narrow and vertically declined (Plate 12, fig. 12). Occipital furrow broad (sag.) and shallow. Occipital ring one-quarter as long as glabella; strongly vaulted; laterally it narrows at first, then widens into occipital lobe, then degenerates a little as abuts against posterior border behind 1p lobe. Small tubercle positioned towards posterior end of occipital ring (Pl. 12, fig. 14). Axial furrows diverge from posterior border, but swing round to converge anteriorly. Fixigena broad posteriorly, being as broad as 1p lobe; gradually narrows forwards as it swings inwards, degenerating outside 2p lobe. Eye ridge separated from genal ridge by a deep furrow; it commences at base of eye lobe, opposite posterior of 1p lobe, then runs parallel to genal ridge, merging and degenerating with it anteriorly. Preglabellar field (Pl. 12, fig. 10) gently upturned medially, more strongly upturned laterally. Posterior border rim very narrow adaxially; broadens (exsag.) laterally, being very swollen where crossed by posterior branch of facial suture. Posterior border furrow concomitantly deepens laterally. Posterior branch of facial suture runs at 45° towards posterior border. Anterior branch of facial suture gradually diverges from eye ridge anteriorly, meeting anterior border in line with posterior part of fixigena. Librigena

(Pl. 12, figs. 15, 17) steeply declined below eye lobe; rapidly widens as declines into broad, shallow border furrow; bounded laterally by rounded narrow border which rapidly widens towards genal angle; at genal angle border extremely swollen where met by short, stout librigenal spine (Pl. 12, fig. 15). Lateral border bears fourteen denticles (Pl. 12, fig. 17). Eye surface sub-spherical, composed of many gently curving rows of holochroal lenses, eye surface bounded ventrally by strong furrow, below which cheek is tuberculated. Borders are tuberculated, those on swollen part being larger than those on narrower borders.

Thorax and hypostome are unknown. Pygidium (Pl. 12, figs. 16, 18, 19) three times as wide as long (excluding spines); bears a triangular axis which comprises a high, convex, wide (tr.) anterior ring, a lower, narrower posterior ring, and a flat triangular plate which joins raised, convex posterior border. Anterior ring develops laterally into a raised pleural ridge which curves postero-laterally at 30° to transverse line, gradually thickening as it approaches border, whereupon it swells appreciably and extends beyond border as major pygidial spine for twice length of minor spines. Semicircular border bears three pairs of minor spines, central two pairs being positioned equidistantly about the sagittal line, whilst third is smaller and develops out of base of major spine. Only one spine present antero-lateral to macrospine; making a total of ten pygidial spines. Axial rings carry small irregularly positioned tubercles. Similar sized tubercles occur on spines and posterior border; become larger and more concentrated at junction of spines with border. Tubercles are also scattered on the flat, depressed pygidial border.

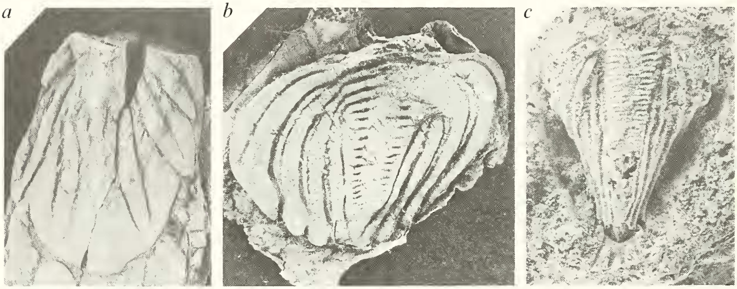
Discussion. Bruton (1967, p. 7) assigned these specimens from Torver to *Primaspis evoluta* (Törnquist). It can be shown that a number of important differences occur which separate this form into a different species. The posterior of the fixigena, the 1p lobe and the central glabellar area are all approximately equal in width in *P. bucculenta*, whereas the central glabellar area is wider than the 1p lobe, which in turn is wider than the fixigena in *P. evoluta* (Bruton 1967, pl. 1, figs. 4, 9). Relative to the 1p lobe, the 2p lobe is larger in *P. bucculenta*. The characteristic indentation of the adaxial part of the 1p lobe in *P. evoluta* is absent in the Lake District species. The occipital ring is shorter (sag.) in *P. bucculenta*. The pygidium of *P. bucculenta* differs from *P. evoluta* in being three times, not four times, as wide as long, and it carries one less spine antero-lateral to the macrospine.

P. semievoluta, Reed 1910, p. 214, pl. 17, figs. 1–3, from the Longvillian of the Cross Fell Inlier has a narrower fixigena than *P. bucculenta*, lacks the minor spine fused to the macrospine on the pygidium and has one extra spine antero-lateral to it. *P. caractaci* (Salter) from the late Caradoc of south Shropshire differs in possessing a greater number of pygidial spines and narrower fixigena (Dean 1963*b*, p. 239, pl. 44, figs. 3, 9). *P. girvanensis* (Reed 1914, p. 33, pl. 5, figs. 8–10; pl. 6, figs. 1–3) from the upper Drummuck Group, Girvan, has a wider central glabellar area, larger 1p lobe, lacks the fused spine on the pygidium and bears two spines antero-lateral to the macrospine.

Coniston Limestone trilobites described and illustrated by McCoy

In his description of Palaeozoic fossils, McCoy (1851) discussed and mentioned eight species of trilobites from the Coniston Limestone of the Lake District, seven of which he figured. The present generic and specific assignments of some of these have been discussed earlier: SM A9569 (McCoy, pl. 1F, fig. 6; Pl. 10, fig. 7 herein) designated by McCoy as *Calymene brevicapitata* Portlock is now believed to be *Gravicalymene susi* sp. nov.; SM A6806 (McCoy, pl. 1F, fig. 10; Pl. 9, fig. 9 herein), one of two illustrated syntypes of *C. subdiademata* McCoy, has been herein selected as the lectotype of that species; SM A41905 (McCoy, pl. 1F, fig. 12; Pl. 8, figs. 9, 11 herein), which McCoy called *Cheirurus clavifrons* Dalman, has been redesignated herein as the lectotype of *Pseudosphaerexochus boops* (Salter).

A pygidium (SM A41909; text-fig. 7*a*), probably from the Applethwaite Formation of 'Coniston', was the basis of the new species *Lichas subpropinqua* proposed by McCoy (1854, pl. 1F, fig. 17) in a footnote to the plate explanation. He had earlier (McCoy 1851, p. 150) questioningly placed it in *L. propinqua* Barrande. Salter (1873, p. 50) later referred it to *L. laciniatus* (Wahlenberg) without comment. Although the specimen has been transversely shortened by lateral compression, it shows the characteristic features of *L. laciniatus*, redescribed by Warburg (1925, p. 295), notably the shape of the pleurae, pleural and interpleural furrows, and the gently rounded postero-lateral borders which meet to form a pointed posterior termination. Reed (1896, p. 427, pl. 31, fig. 10) described *L. conformis keisleyensis* on the basis of a pygidium from the Keisley Limestone. This form appears to be identical with that from the Lake District. Warburg (1925, p. 300) referred this subspecies to *L. laciniatus*, as did Dean (1974, p. 79).



TEXT-FIG. 7. Three pygidia from the Applethwaite Formation figured by McCoy (1854, pl. 1F, fig. 17, *a*; pl. 1G, figs. 2, 3, *b*; pl. 1G, fig. 8, *c*): *a*, *Lichas laciniatus* (Wahlenberg), SM A41909, internal mould from 'Coniston'; *b*, *Atractopyge verrucosa* (Dalman), SM A41904, cast of external mould from Applethwaite Common; *c*, *Cybeloides* (*Paracybeloides*) *girvanensis* (Reed), GSM Zl 9108, internal mould from 'Coniston Water'.

McCoy (1851, p. 157) based the species *Zethus atractopyge* on two pygidia, one SM A41904 (McCoy, pl. 1G, figs. 2, 3; text-fig. 7*b* herein) from the Applethwaite Formation of 'Applethwaite Common', the other, SM A41875 (McCoy, pl. 1G, figs. 5, 6) from the mid-Caradoc near Meifod, and an incomplete partly disarticulated specimen (SM A41903) from 'Ravenstonedale' (McCoy, pl. 1G, fig. 1). Dean (1961, p. 319) subsequently chose the Meifod specimen as the lectotype of *Atractopyge atractopyge*. This pygidium differs from the Lake District form in possessing a pygidial axis which tapers less rapidly posteriorly. The 'Ravenstonedale' specimen (a disarticulated cephalon and thorax, not a pygidium as stated by Ingham (1975, p. 81) can, on account of the almost equi-sized 2p and 3p lobes, be assigned to *A*. cf. *verrucosa* (Dalman), as can the Lake District form. This species is based on a recently rediscovered cranidium (see Dean 1974, p. 97, text-fig. 4), probably from the Crûg Limestone, south Wales. Cranidia collected from the same area in the Lake District as the pygidium SM A41904 are like the type specimen of *A. verrucosa*.

McCoy (pl. 1G, fig. 8) illustrated, though did not discuss, a pygidium (GSM Zl 9108) from 'Coniston Water' (text-fig. 7*c*) which he called *Z. rugosus* (Portlock). This pygidium is reassigned to *Cybeloides* (*Paracybeloides*) *girvanensis* (Reed).

The three specimens (SM A41906–41908) from Sunny Brow, which McCoy (p. 172, pl. 1G, figs. 33–35) assigned to *Illaenus rosenbergi* Eichwald, formed the basis of a new species, *I. marshalli*, erected by Salter (1867, p. 200). Later authors, including Eichwald (1860, p. 1483), retained this species in *I. rosenbergi*. The cranidium (SM A41906), however, has a much shorter eye lobe than that of *I. rosenbergi* (Eichwald 1825, pl. 3, fig. 3). As Ingham (1970, p. 25) suggested, these poorly preserved specimens appear to be identical with *Stenopareia bowmanni* (Salter). The alleged distinctive feature of '*I. marshalli*' was the surface pattern of irregular rugae. These, however, parallel the cleavage direction and are consequently considered to be tectonic features associated with transverse shortening. Salter, in erecting *I. marshalli*, further considered that the eye lobe was positioned closer to the glabella, yet further forward than in *S. bowmanni*. In comparison with topotype material of *S. bowmanni* figured by Price (1974, pl. 112, figs. 1–8), there appears to be no appreciable difference in eye lobe position between the two forms. Salter's (1867, pl. 29, fig. 3) figure of the Lake District cephalon erroneously shows the right eye lobe closer to the glabella than it is on the actual specimen.

Lastly, the specimens from 'Applethwaite Common' and 'Coniston Water Head' which McCoy (1851, p. 164) referred to *Chasmops odini* (Eichwald) belong to *Toxochasmops marri* (Reed).

Acknowledgements. Professor H. B. Whittington, and Drs. J. K. Ingham and C. P. Hughes have proffered useful suggestions for the improvement of this work, for which I am grateful. Drs. D. Price (SM), A. Rushton (GSM), R. Fortey, S. Morris (BM), and J. K. Ingham (HM) have kindly lent material in their care. Assistance in the field was given by Professor and Mrs. H. B. Whittington, S. Radford, and S. Conway Morris, to all of whom I offer my thanks. Much of this work was carried out whilst in receipt of a N.E.R.C. Studentship at the Sedgwick Museum.

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Typescript received 22 February 1978

Revised typescript received 5 June 1978